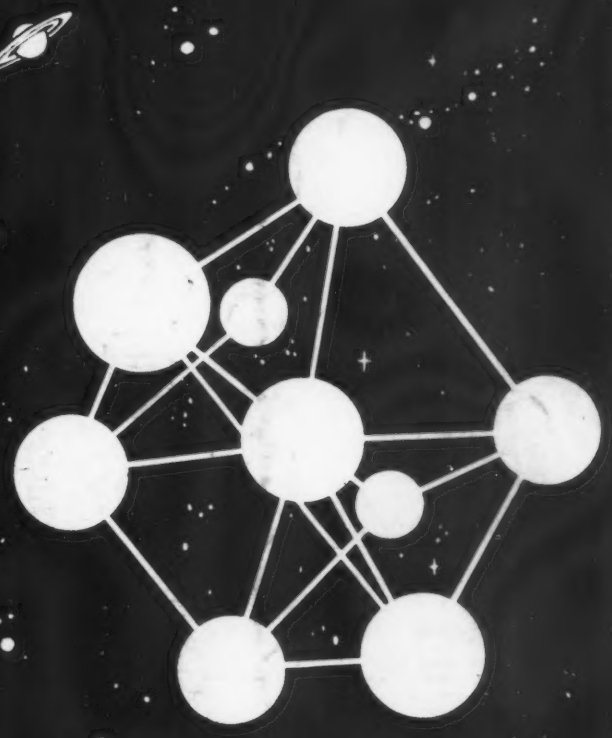
NUCLEAR ENERGY

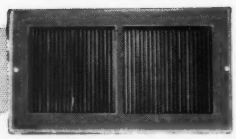
THE JOURNAL OF THE INSTITUTION OF NUCLEAR ENGINEERS

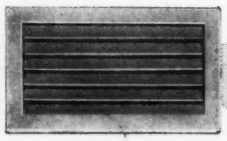


GOLD MEDAL
AWARD 1960

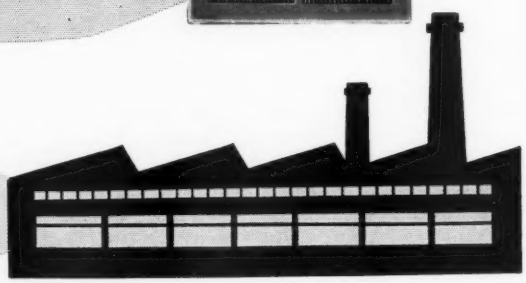
GRILLES and REGISTERS

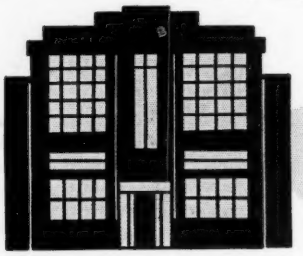
residential



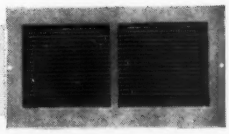


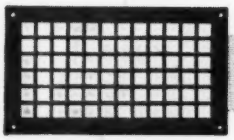
industrial



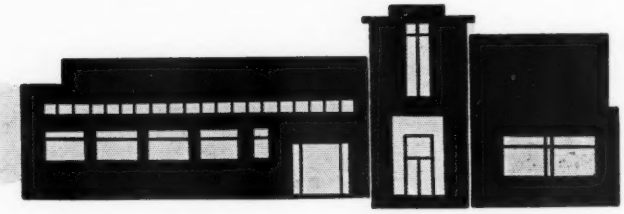


commercial





medical



Phone or write for catalogue of grilles and registers

ACE
TRADE MARK

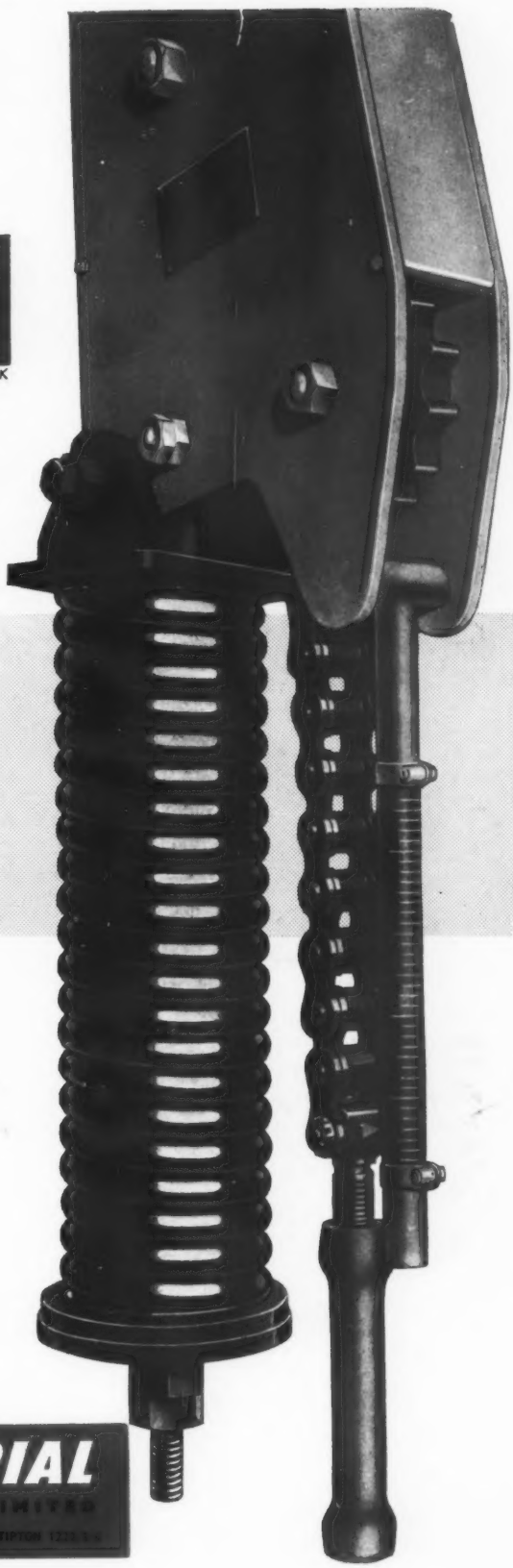
AIR CONDITIONING & ENGINEERING (N.I.) LTD.,
TANDRAGEE, CO. ARMAGH, NORTHERN IRELAND.
P.O. BOX 8, PORTADOWN, N. IRELAND, PHONE TANDRAGEE 214

For controlled pipe movement . .

CON-TEN

REG. TRADE MARK

CONSTANT TENSION PIPE SUPPORTS



The Con-Ten system has not only been tested, but *proved* in industries and power stations all over the world. No matter what the load or the pipe movement, or the problems met, there is a Con-Ten to provide the most adequate and *permanent* support available. Loads from 100 lbs. to 14 tons and pipe movements up to 18" can be controlled by constant tension supports in the Con-Ten range.

Contact us now for full information

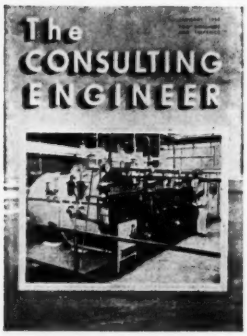
British Patent Nos. 474008, 720074 720075, 697987, 816976
U.S.A. Patent No. 2129320

BRITISH INDUSTRIAL

ENGINEERING COMPANY (STAFFS) LIMITED

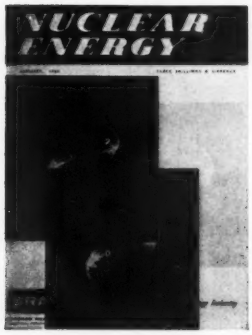
CORONATION WORKS HARROP ROAD, TIVIDALE, TIPTON STAFFS. Telephone: TIPTON 1225 5 lines

The PRINCES PRESS Group

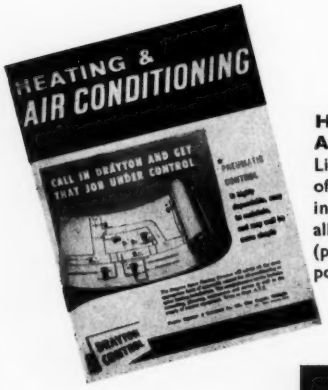


THE CONSULTING ENGINEER
Detailed, profusely illustrated articles, news and information. Monthly. 3/6d. (Postage 2/-) 12 issues 42/- post free.

Printed and published
by
PRINCES PRESS LTD.
147, Victoria Street,
Westminster,
London, S.W.1
Telephone: Victoria 6423



NUCLEAR ENERGY
All aspects of nuclear energy in industrial use, science, medicine, education, etc. Monthly. 3/6d. (postage 2/-) 12 issues 42/- post free.



HEATING & AIR CONDITIONING
Lively, authoritative coverage of trade and technical matters in heating, ventilating and allied fields. Monthly. 3/6d. (postage 2/-) 12 issues 42/- post free.

THE CIVIL ENGINEER
Articles, news and pictures and trade and technical matters in the civil engineering field. Monthly. 3/6d. (postage 2/-) 12 issues 42/- post free.

WORLD AIRPORTS
Articles and illustrated features covering all aspects of airport operation and maintenance, including construction, furnishing, equipment and facilities. Monthly. 2/6 (postage 2/-); 12 issues 42/- including postage.

EUROPEAN ENGINEERING
News, trade features and technical articles for buyers and sellers within Europe and from Europe to the rest of the world. A separate section for each European country or bloc. Alt. Months 3/6 (postage 2/-); 12 issues 42/- post free.

Also available . . .

The Consulting Engineers Who's Who & Year Book 1961

Published in Collaboration with the Association of Consulting Engineers.
In addition to Members' and Firms' Who's Who sections, contains much other useful information. Cloth bound, 8vo. 42/- post free.

Temperature & Degree Days—Season 1959-60

Monthly tables of official min/max/mean temperatures and degree days.
Pocket Size. 1/- post free.

MATHEMATICS IS EASY—by D. S. Watt, BSc, pp. 488. Figs. 109. Cloth bound. 48s. net. With this book it is possible to learn mathematics from the first equation to the most advanced calculus.

PHYSICS IS EASY—by D. S. Watt, BSc, pp. 560. Figs. 123. Cloth bound. 63s. net. Second in the 'Easy' series, bringing a fascinating subject within the reach of all. Profusely illustrated with photographs and drawings.

"PLANNAIR" GAS CIRCULATION BLOWERS FOR NUCLEAR PROJECTS

Carbon dioxide circulator for fuel element cluster, here illustrated, provides for reliable and efficient cooling of nuclear reactors. The blower, with its 11,500 r.p.m. motor (200V 400 c/s supply), is sealed within a long pressure vessel at the opposite end to which the nuclear reaction occurs. CO_2 circulates through the tube at 285 p.s.i. A and 95°C. The blower output is 6300 lb./hour at 7.5 p.s.i. pressure differential. A secondary radial impeller gives a cooling gas circuit via a demineralised water heat exchanger coil which keeps the motor operating at below 75°C.

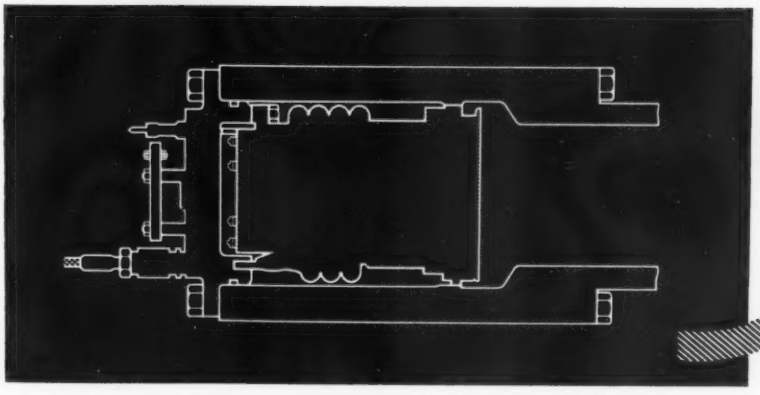
This is but one of several gas circulating blowers which Plannair have designed for various nuclear projects. These include a Leaky Cartridge Test Rig Air-Blower, a Sodium Loop-Nitrogen Circulator, a Helium Circulator, Air Circulators and a Nitrogen Circulator, CO_2 circulator for Fuel Element Cluster Irradiation Test Rig, Burst Fuel Element Test Rig Air-Blower.

Ambient pressures in which these circulators are designed to work range from normal atmospheric to 300 p.s.i. at temperatures up to 350°C. Pressure rises through circulators extend up to 30 p.s.i. and mass flows through units cover a range up to 8000 lb./hour.

Circulators are usually of the high speed motor driven type with specially designed impellers, motors being gas and liquid cooled.

Zero leakage is an important feature of these designs.

Further details available on request.



PLANNAIR

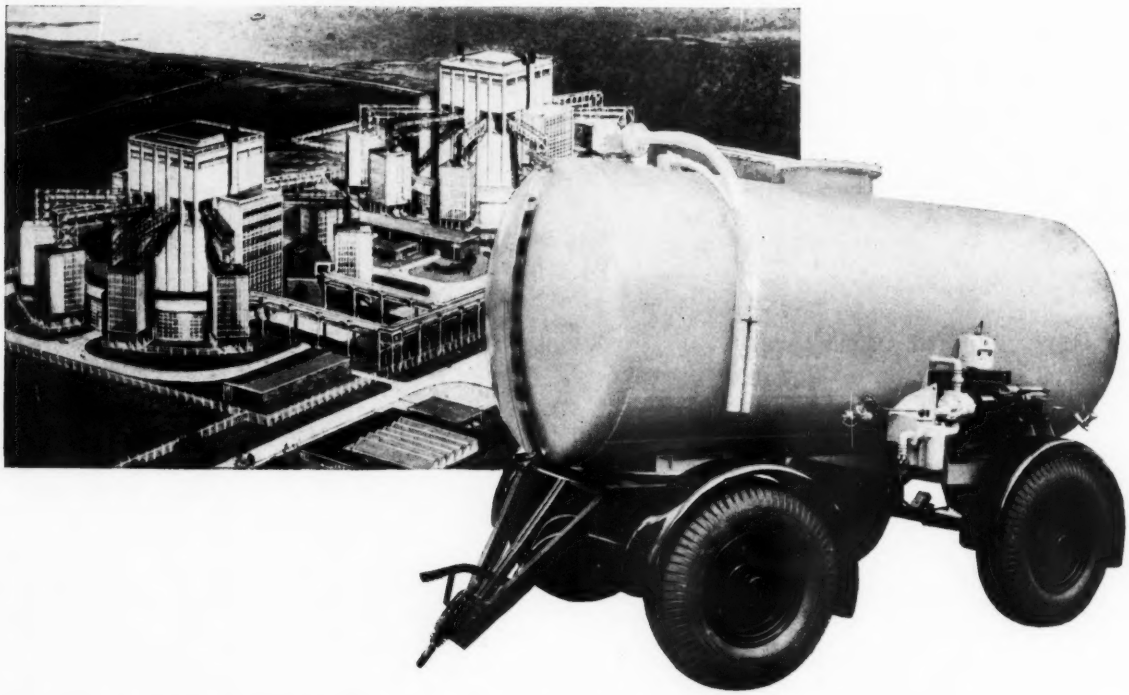
PLANNAIR LIMITED

Windfield House • Epsom Road

Leatherhead • Surrey

Tel: Leatherhead 4091/3, 2231

PLA39



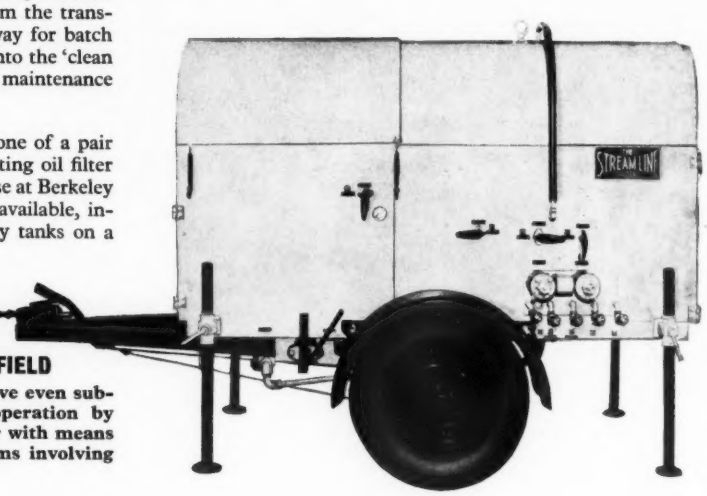
STREAM-LINE mobile filtration plant

To meet the special demands of maintenance engineers in nuclear power and similar applications, Stream-Line now supplement their range of insulating oil purifiers by the addition of large capacity mobile tanks. The Stream-Line filter is already well known for its efficiency in keeping insulating oil free from all solid, liquid and gaseous impurities; now, combined with two tanks (one for dirty, one for clean oil) it makes possible a completely mobile, extremely versatile filtration plant. Oil can be pumped quickly from the transformer into the 'dirty' tank and either taken away for batch filtration or filtered on site and passed straight into the 'clean tank'. While the oil is being purified essential maintenance work can be carried out on the transformers.

The 1,000 gallon tank illustrated above is one of a pair supplied with a 250 g.p.h. Stream-Line insulating oil filter to the British Thomson-Houston Co. Ltd., for use at Berkeley Power Station. Larger capacity tanks are also available, including models which combine clean and dirty tanks on a single transporter.

SUPER EFFICIENCY

For applications demanding super efficiency in the elimination of last traces of air and water, Stream-Line high vacuum filters (Type CN-HV) are available operating at pressures in the order of 0.1 mm. Hg., compared with the 28″/29″ Hg. vacuum employed by medium vacuum (CN) types. Outputs range from 50 to 1,500 g.p.h.



OTHER APPLICATIONS IN THE NUCLEAR FIELD

The ability of the Stream-Line filter to remove even submicronic particles, coupled with ease of operation by remote control, provides the nuclear engineer with means for dealing with some of his special problems involving radio-active materials.

STREAM-LINE

STREAM-LINE FILTERS LIMITED
HENLEY PARK, NORMANDY, NR. GUILDFORD, SURREY

Telephone: Normandy (Surrey) 3311-3 Telegrams: Edgefilt, Guildford

A member of the VOKES Group

SF108

THE FIRST NAME YOU THINK OF FOR HEAT TRANSFER SURFACES

Heating coils, cooling coils and air-cooled condensers. We make 'em. Promptly. To meet *every* individual need and design.

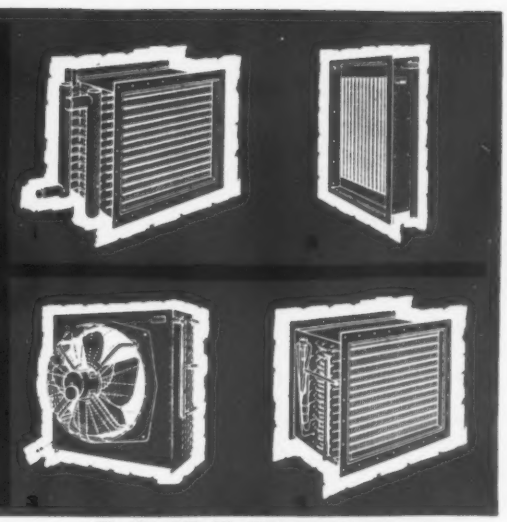
Our customers enjoy a speedy and truly personal service backed by high standards of workmanship—let us quote you *promptly* for your next job!

AIR-COOLED CONDENSERS
A wide range of standard models, covering small and large air-flows.

COOLING COILS
Brine, Chilled Water and Direct Expansion Refrigerants including coils for Solvent Recovery.

HEATING COILS
For all systems, using steam or hot water.

The illustrations on the right are:—
1. Chilled Water Coil. 2. Air Heater for steam.
3. Air-cooled condenser. 4. Direct expansion cooling coil

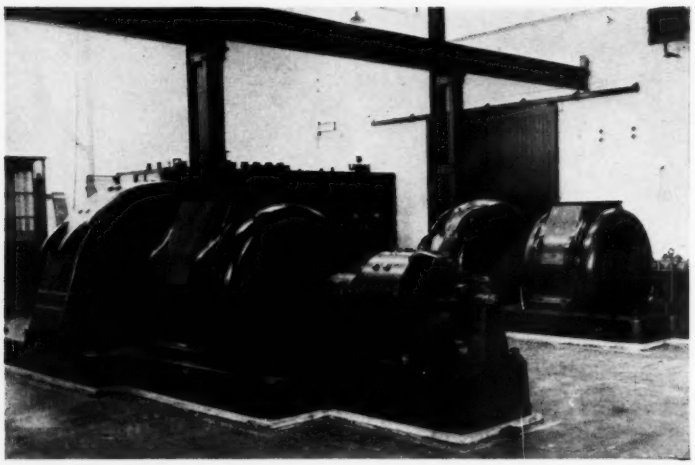


UNITED AIR COIL LTD LONDON

14, TRINITY ST., LONDON, S.E.1. Tel: HOP 7421/4

UNITED AIR COIL

Electrical Plant for Special Applications

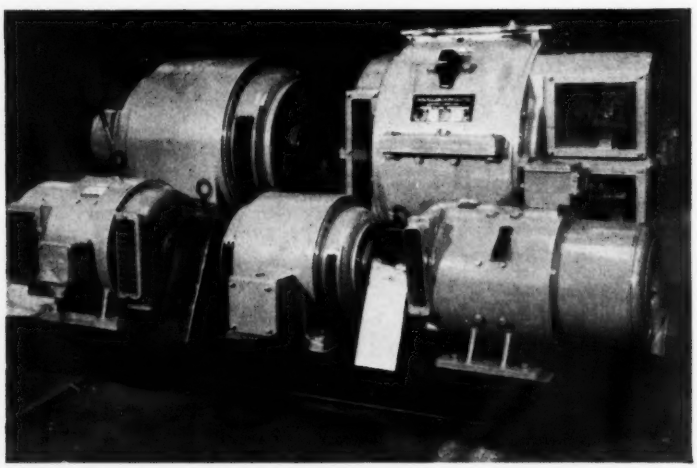


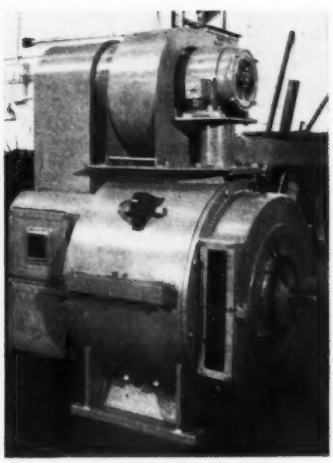
500 kW and 750 kW foreground MOTOR GENERATOR SETS by General Electric Co. ; input 400 volts 3 phase 50 cycles, output 230 volts D.C.

The above sets are now being installed for use in one of the U.K.A.E.A. Establishments

Send us Your Enquiries for :

FREQUENCY CHANGER EQUIPMENT
WARD LEONARD SETS
MOTOR GENERATOR SETS
PLATING AND ANODISING GENERATORS
A.C. AND D.C. MOTORS
ALTERNATORS
WELDING GENERATORS
TRANSFORMERS
SWITCHGEAR—HAND AND AUTOMATIC





Special Ward Leonard Equipment supplied by us for driving a Plastic Calender.

Above : Main motor generator set, output 0/220 volts, 200 kW max. In the foreground auxiliary set giving two D.C. voltages for drives to the calender. Right : Work motor 240 h.p. 0/330 volts D.C., speed range 0/1500.

FOR ROTATING ELECTRICAL MACHINES TO SPECIAL REQUIREMENTS

GEORGE COHEN

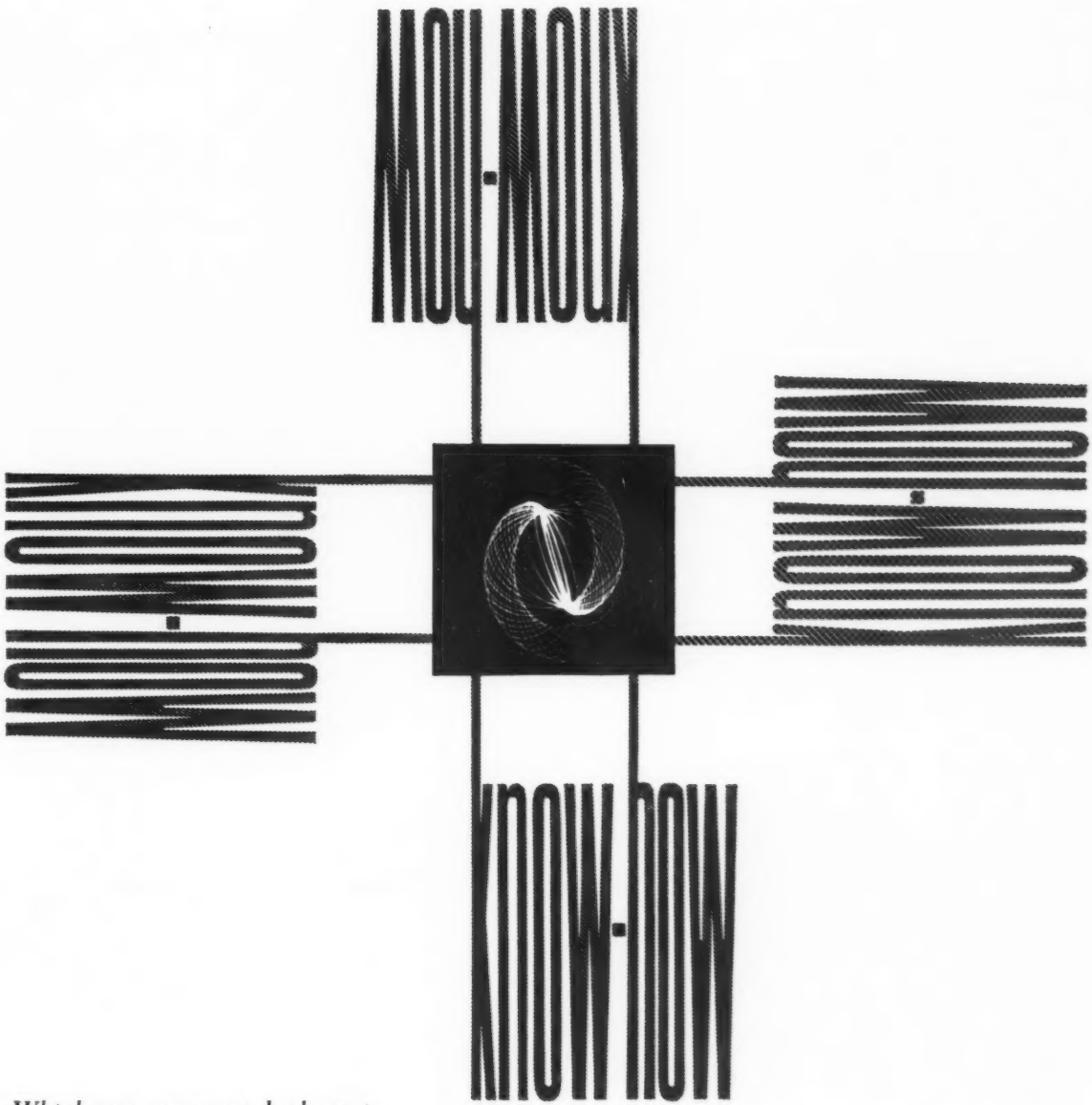
SONS AND COMPANY LIMITED

WOOD LANE, LONDON, W.12 Telephone: SHEpherds Bush 2070

STANNINGLEY, Nr. LEEDS Telephone: Pudsey 2241

And at Kingsbury (Nr. Tamworth), Manchester, Glasgow, Bath, Swansea, Newcastle-on-Tyne, Belfast, Sheffield, Southampton

THE 600 GROUP OF COMPANIES



Whichever way you look at it . . .

know-how is of primary importance in the manufacturing of Atomic Energy Equipment. This is where Graviner scores, for we can make almost anything in this rather new sphere of activity, whether it be a lead-filled shielded container, a Thulium storage magazine, a magnet for neutron beam focusing or a 20 ton mobile cell unit with viewing windows and handling equipment. We specialise too, in the machining of graphite. Indeed, with the recent addition of 12,500 square feet of factory space we can deal with anything from the making of a tiny graphite spring to a Reflector for a Reactor — all under controlled clean conditions.

If therefore you have a Development or Production problem, our Nuclear Energy Division will be very pleased to help you. Won't you pay a visit to the Gosport Factory and see what we can do ?

GRAVINER *Contractors to The Atomic Energy Authority*

FAREHAM ROAD · GOSPORT · HAMPSHIRE · Telephone Fareham 2511

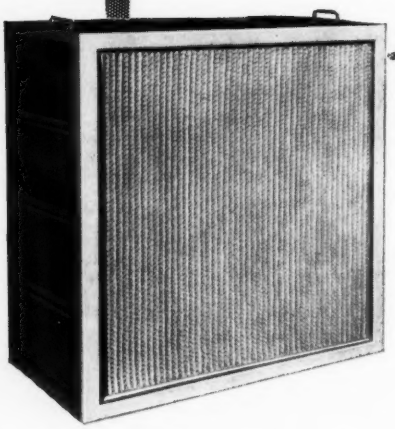
Also specialists in Airborne, Diesel Engine and Industrial Fire and Explosion Protection, Thermostats and Overheat Switches

A speck of dust 1/10,000

of a millimetre in size has only

one chance in 10,000 of getting

past this Vokes 'Absolute' Filter



Other filters in Vokes 'Absolute' range include the standard type (guaranteed 99·95% efficient against sub-micronic particles) and high humidity and acid resistant types (guaranteed 99·99% efficient against sub-micronic particles).

...and that's guaranteed

Vokes 'Absolute' high temperature filters were developed for critical applications involving risk of fire, or temperatures up to 1000 F. They have proved particularly valuable in the filtration systems of nuclear power stations where a breakdown caused by an outbreak of fire might release dangerous toxic particles to atmosphere.

These filters have a guaranteed *minimum* efficiency of 99·99% against particles in the 0·1 to 0·5 micron range: therefore impurities in the air ranging in size from a ten thousandth of a millimetre to a two thousandth of a millimetre have only one chance in ten thousand of passing through the high temperature 'Absolute' all glass paper filter medium.

In addition Vokes *guarantee* the accuracy of these figures. As with all Vokes 'Absolute' filters, every high temperature type is tested in accordance with BSS 2831 on a methylene blue test rig and rejected if its efficiency is below the required standard.

You are invited to write for a booklet covering the range of Vokes special purpose air filters and containing details of Vokes unique testing methods.

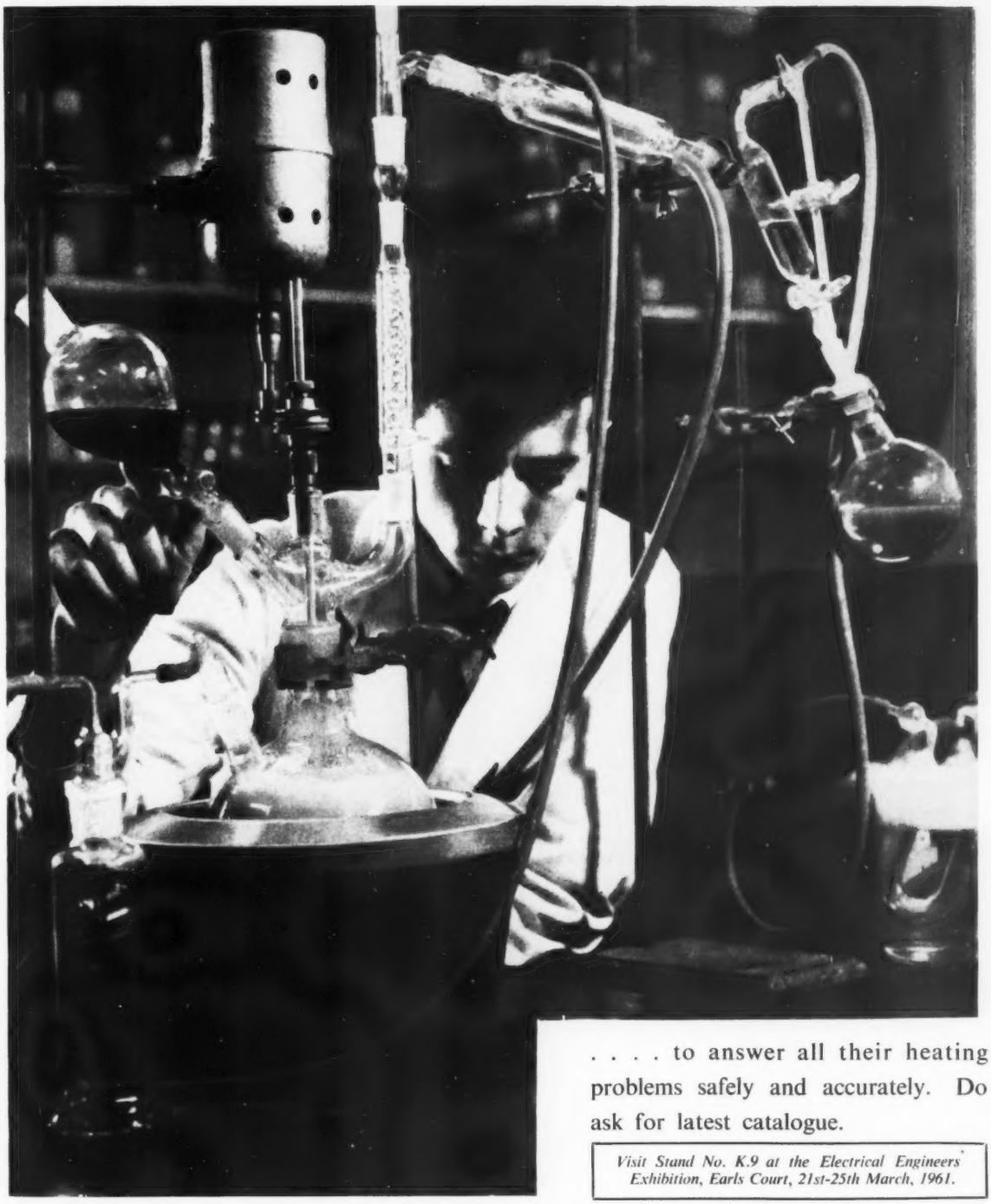
VOKES leave ***absolutely*** nothing to chance

VOKES LIMITED · HENLEY PARK · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines) Telegrams: Vokesacess, Guildford, Telex. Telex: 8-535 Vokesacess, Gfd. *Represented throughout the world*

V.550

Chemists rely on ISOMANTLES



. . . . to answer all their heating problems safely and accurately. Do ask for latest catalogue.

Visit Stand No. K.9 at the Electrical Engineers' Exhibition, Earls Court, 21st-25th March, 1961.

Isomantle used at Laporte Titanium, Grimsby

ISOPAD LTD., BARNET BY-PASS, BOREHAM WOOD, HERTS.
Telephone: ELStree 2817 9-3602

ISOPAD ELECTRIC SURFACE HEATERS

Time and time again

TIME PAST

Vokes Genspring hangers were introduced to provide constant support for high temperature pipework over a wide range of vertical movement. One of the applications for which they were specified was the support of pipework at the then revolutionary nuclear power stations at Calder Hall and Chapel Cross.

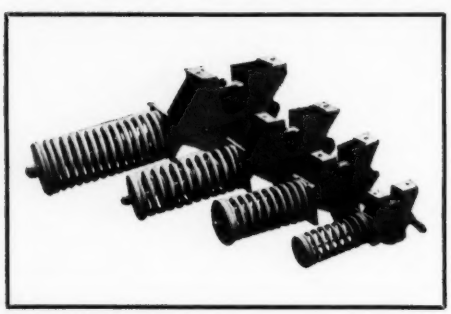
TIME PRESENT

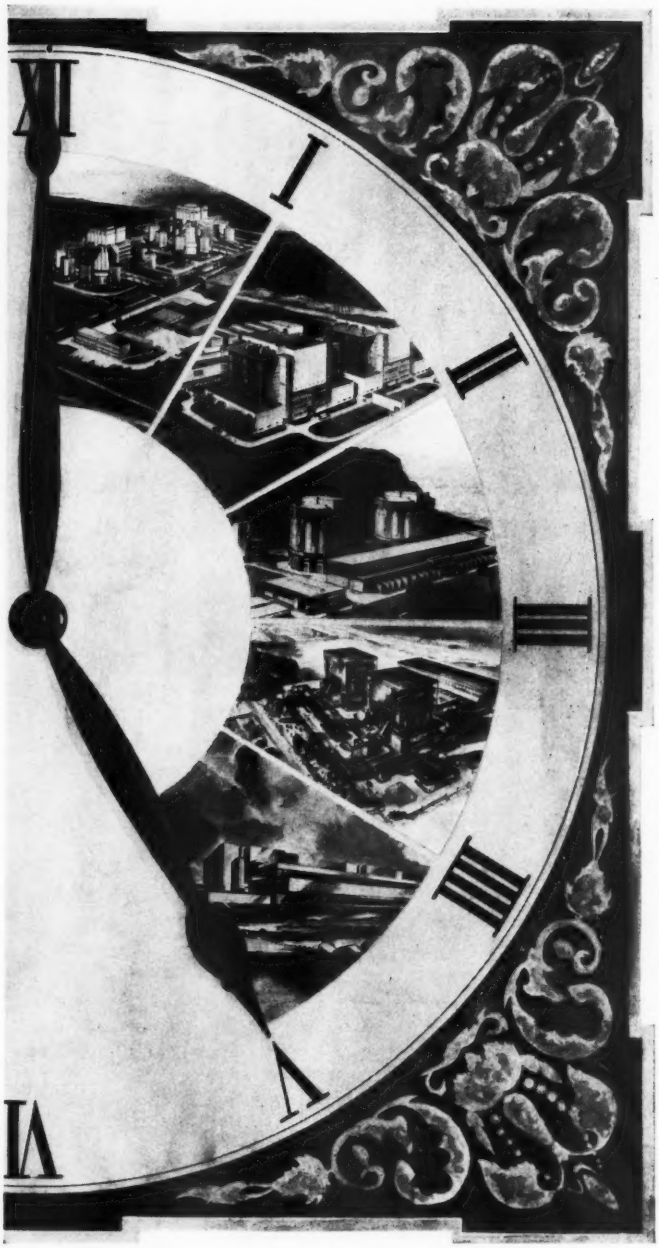
Such was their success that we are now privileged to supply suspension equipment to the five members of the Nuclear Consortia for the five latest Nuclear Power Stations. A new Genspring capable of supporting 97,800 lb. with 12″ vertical travel has been built mainly for use in Nuclear Power applications.

TIME FUTURE

Vokes Genspring have thus built up a unique fund of specialised knowledge which will prove invaluable in overcoming new pipe support problems which the power stations of the future will almost certainly present.

M1 to M4 Constant Supports covering loads from 315 lb. to 22,500 lb. and travels from 1.5″ to 12″. The latest addition to the range is Type M7 for loads up to 97,800 lb.





The illustrations above are artists' impressions of the Nuclear Power Stations at Berkeley (A.E.I.—John Thompson Nuclear Energy Co. Ltd.); Bradwell (The Nuclear Power Plant Company Ltd.); Hunterston (G.E.C.—Simon-Carves Group); Hinkley Point (English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group) and Trawsfynydd (Atomic Power Constructions Ltd.).

Vokes Genspring SUSPENSION SYSTEMS

VOKES GENSPRING LIMITED · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines) Telex: 8-535 Vokesacess, Guildford. Telegrams & Cables: Vokesacess, Guildford, Telex.

A member of the VOKES Group

VG47

NUCLEAR ENERGY

Journal of the Institution of Nuclear Engineers

President
Sir John M. Duncanson

Vice-President
D. S. Watt, BSc

Junior Vice-President
F. L. Coombs, LLB, AMIEE

Secretary
J. B. Pinkerton, MConsE, MIMechE

Council Members
N. S. Grassam, PhD, BSc(Eng), J. Moore, BSc(Hons), H. F. Jones, AMIE, F. R. Paulsen, BSc, PhD, FRIC, FCS, A. E. Merrin, BSc, P. Spear, J. C. Bradbury-Williams, AMIMechE, A. Wyatt, H. E. Cooper, H. J. Winch.

International Commercial Representatives

U.S.A. & Canada: *TPR Inc.*, 261, Madison Avenue, New York 16, N.Y. Tel. No. Yukon 6-9933.

South America: *J. de Croze*, Rua Mexico, 70, S/110, Rio de Janeiro, D.F., Brazil.

Belgium: *Organisation Internationale De Regies Publicitaires, Omnium Publicité S.A.*, 38, rue Ernest Allard—Bruxelles 1. Tel. 12.92.34—11.07.40.

Denmark: *Messrs. Moyell & Moyell*, 19, Store Strandstraede, Copenhagen, K. Tel. Byen 8140.

Holland: *N.V. Uitgeversmij Diligentia*, Roemer Visscherstraat 2-4-6, Amsterdam. Tel. 18.60.11.

W. Germany & Switzerland: *Linder Presse Union, GmbH*, Wittelsbacher Allee 60, Frankfurt/Main. Tel. 46372.

Annual Subscriptions: Sterling Area:—12 monthly issues 42*s.* 0*d.* (including postage); Americas:—$10.00; Other Countries:—As Sterling Area.

A PRINCES PRESS PUBLICATION
147 Victoria Street,
London, S.W.1. **VIC. 6423-4**

MARCH 1961

CONTENTS

PAGE

The Role of Steam Generators at Nuclear Power Stations Using Water Coolant, by T. Kh. Margulova 105

Design and Operation of the Radiochemistry Laboratory, by G. R. Hall 111

America's Record Atom-smasher, by F. R. Paulsen 114

Gamma Radiography of the Bronze Door of Gniezno Cathedral, by Zbigniev Godlewski 119

Classroom and Laboratory 121

Institution News 124

Book Reviews 125

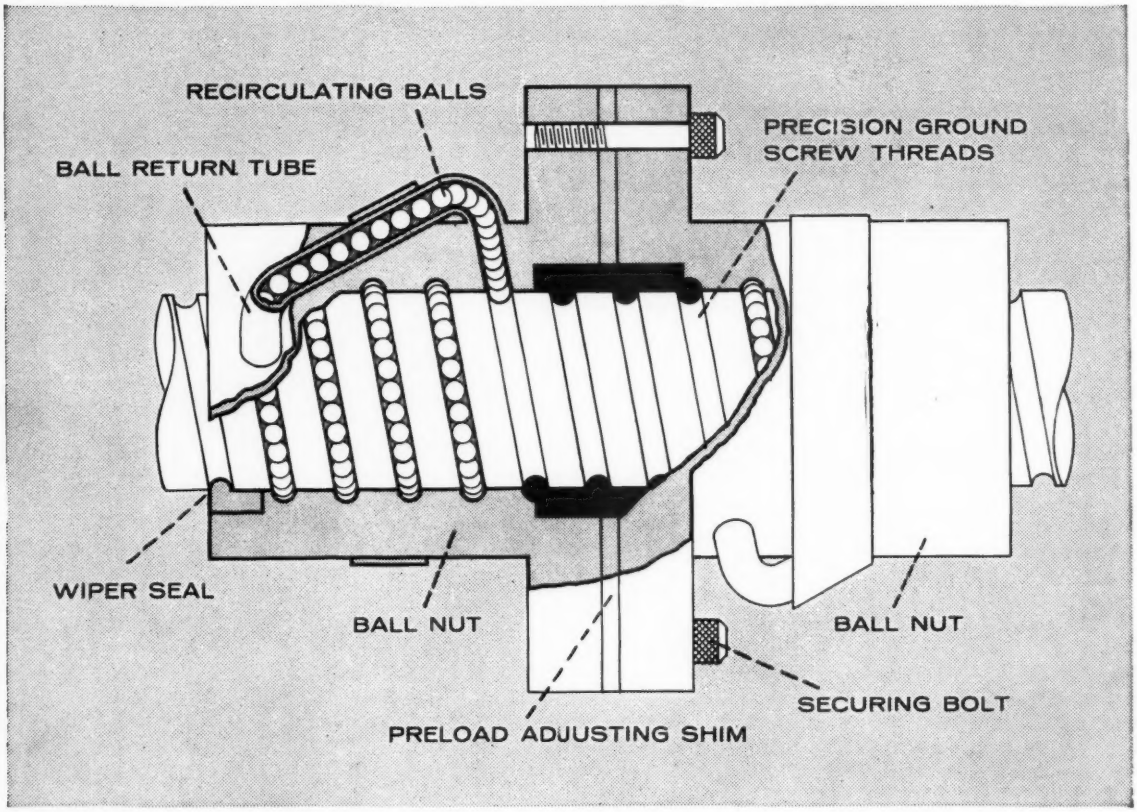
Westminster Talks About, by Peter Lewis 126

Nuclear Notes 127

Equipment and Materials 131

ISOTOPE WORLD

Isotope Symposium in Bangkok 133



Beaver pre-loaded ball screws, up to 95% efficient, operate at—52°C to over 400°C with no backlash

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of—52°C to 400°C without lubrication, and up to 170°C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

**Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to J. B. Starky, Sales Manager (Ball Screws and Splines), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

The role of steam generators at nuclear power stations using water coolant

by T. Kh. Margulova, U.S.S.R.

STEAM generators are an essential component in some types of nuclear power stations. Among these are nuclear stations using steam turbines in conjunction with reactors cooled by liquid metals, organic substances, gas or pressurized water. Indirect-cycle steam generation is used for all these stations.

When boiling water reactors are used, steam generators cannot be included in the station design. In such cases only a single primary system is provided, which considerably reduces equipment costs. Indirect-cycle systems should also be used when a separate steam generator is included, mainly because of water condition considerations.

Water Purity

With nuclear reactors, water purity is most important with respect to both ionizable impurities, especially combinations of Ca, Mg and Cl-ion, and to the contents of corrosion products. The much more stringent requirements for reactor water purity as compared with those for conventional power station boilers are due to the fact that reactor thermal loads and the number of parallel channels are many times greater and the cross-sectional areas of the channels are smaller. Modern demineralizers supply water of very high quality. Therefore the impurities brought into a nuclear power station system with make-up water prepared in demineralizers, chemical or thermal, are negligible. This leaves two impurity sources, (i) corrosion of station equipment, and (ii) condenser leakage which introduces undesirable scale-forming Ca and Mg-ions into the water.

The quantity of corrosion products in the water depends on corrosion intensity, the extent of corrosion products transfer to the water and the areas of the surfaces subjected to corrosion. Use of austenitic stainless steel, type 18/8, reduces the intensity of corrosion and the transfer of corrosion products into the water is arrested, since after a while a stable oxide film is formed on the surfaces. However, making all power station equipment of austenitic stainless steels is an extremely expensive solution. If the station is an indirect-cycle one, the area of surfaces from which corrosion products are transferred into reactor water is reduced and stainless steel need be used only for the primary loop. Secondary loop equipment can be made of carbon steels.

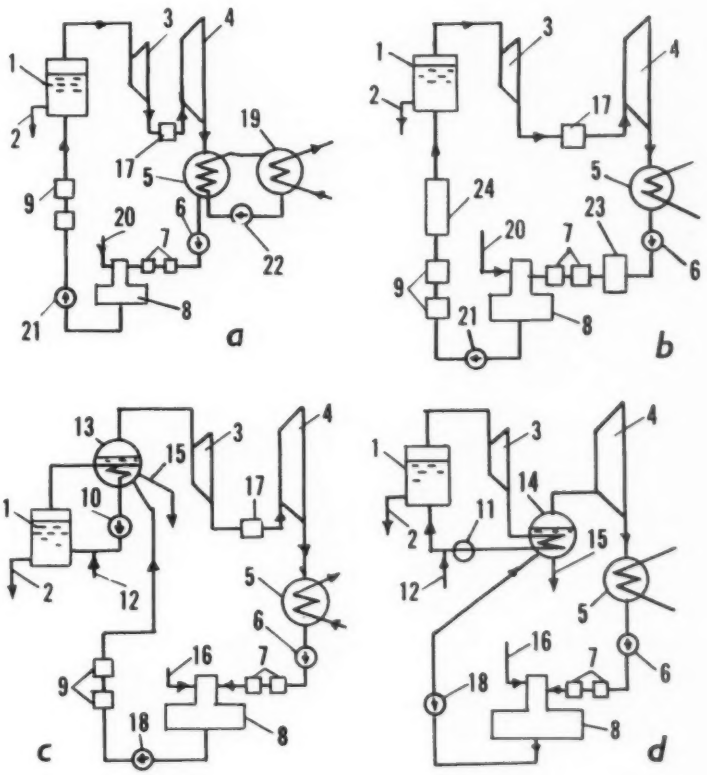


Fig. 1.—Nuclear power station layouts with boiling water reactor and saturated-steam turbine. Key: 1 Boiling water reactor; 2 Reactor blowdown; 3 Medium-pressure turbine cylinder; 4 Low-pressure turbine cylinder; 5 Condenser; 6 Condensate pump; 7 Low-pressure reheaters; 8 Deaerator; 9 High-pressure reheaters; 10 High pressure circulating pump; 11 Medium-pressure circulating pump; 12 Primary loop make-up; 13 Medium-pressure steam generator; 14 Low-pressure steam generator; 15 Steam generator blowdown; 16 Secondary loop make-up; 17 Turbine separator; 18 Steam generator feed pump; 19 Circulating water cooler for condensate; 20 General station make-up; 21 Reactor feed pump; 22 Cooling water circulating pump; 23 Cation rapid filters; 24 Filters for corrosion product removal

Shell achievement

One of Shell's recent achievements in Industrial Lubrication has been to reduce the risk of skin trouble for machine operators. Until the new Shell Dromus range, most modern soluble cutting oils contained phenolic compounds, which can cause skin irritation. They were used as coupling agents between the actual oil and the emulsifier. On high-speed machines, especially, the water evaporates and the emulsion concentrates. And that's when the trouble can start. Shell scientists found a better coupling agent, and made it work. And now, at no extra cost, management can reduce working risks for their staff. *Write for the booklet 'Selecting Your Cutting Oils' to Shell-Mex House, London.*

SHELL

SHELL INDUSTRIAL OILS

On the other hand, carbon steels can be used for the whole station. This solution is the least expensive but the corrosion rate is much higher for carbon steels than for austenitic stainless steels and practically all the corrosion products pass into the reactor water. An acceptably weak corrosion product concentration might be obtained either by installing a filter before the reactor to retain the steel corrosion products or by using high blowdown values for the reactor. The former is promising and will be discussed below: the latter, however, is not economical in its pure form. The possibilities of increasing reactor blowdown without increasing expense are discussed below.

Condenser Leakage

To completely avoid leakage of cooling water into the condensate is almost impossible. The rolled joints are the most probable places for leakage. There are no complaints about leakages in rolled joints of vapour-forming tubes in boilers of conventional thermal power stations. But for these boilers there are far fewer rolled joints and rolling tightness is provided more readily by the greater tube wall thickness and the depth of insertion into thick-walled drums and manifolds. Defective rolled joints in a steam boiler are easily discovered and do not affect water conditions.

By using slightly greater wall thickness for tubes and tube sheets and by covering the latter with tightening plaster, cooling water leakages at the places where the tubes were rolled can be practically eliminated in the condenser as well. However, one remaining possibility of cooling water leakage is that caused by even very slight corrosive destruction of any of the numerous condenser tubes. Leakage of the order of 0.001 per cent. corresponds to a penetration rate of cooling water into condensate of only 4 litres/hr for a 100 MW turbine. Finding such a leakage by present analytical methods is extremely difficult and sufficiently accurate automatic devices do not yet exist. Therefore, when a power station is being designed, the possibility should be borne in mind, of such leakages occurring, even with the highest possible condenser tightness. It is for this reason that at plants operating on very high parameters it is usual, and at those operating on above-critical parameters it is essential, to soften either the full flow of water or a considerable part of it in rapid filters.

Scale-forming ions penetrating with leakage are not troublesome for components in the secondary loop since the steam generator permits inter-drum treatment with phosphates. However, phosphate treatment cannot be used for the primary loop: the formation both of scales and flocks is dangerous to the reactor owing to the possibility of sedimentation in the core. In the indirect-cycle system the effect of condenser leakage on the reactor water conditions is eliminated and this fact, of course, favours this system. Nevertheless, one should bear in mind that a filter arrangement for condensate softening is a considerably cheaper solution than the use of an indirect-cycle scheme with steam generators. Some complications may arise in connection with the fact that the filter would have to work on an active condensate. However, oxygen activity abates quickly and the main problem will probably be Na-activity,

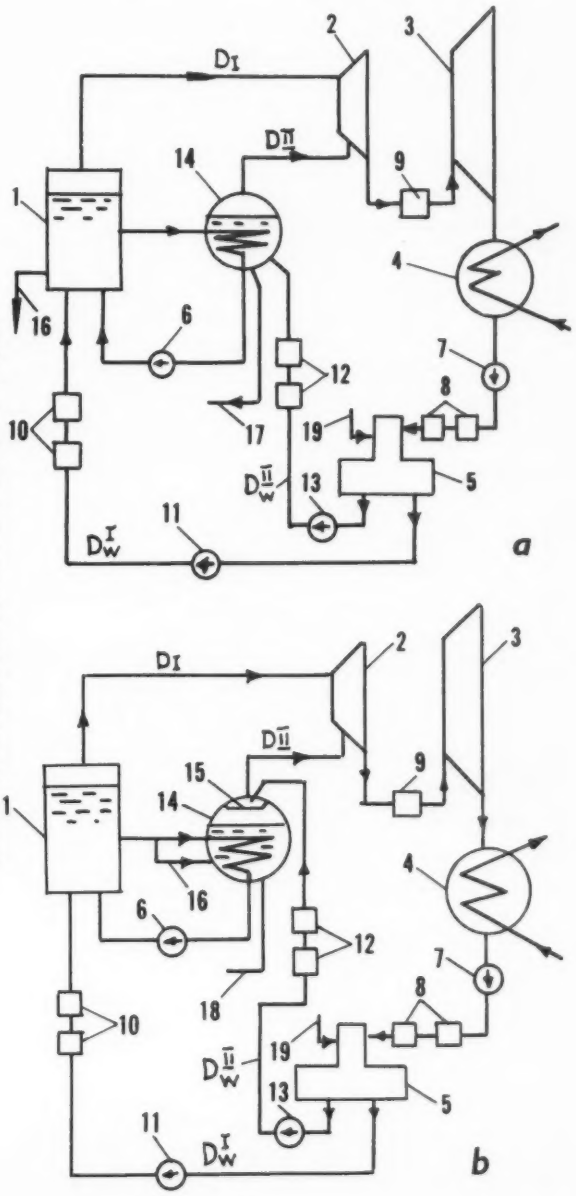


Fig. 2.—Direct-cycle schemes of a nuclear power station of Dresden type with boiling water reactor, saturated-steam turbine and medium pressure steam generator, (*a*) without using stepped evaporation; (*b*) by using stepped evaporation.

Key: 1 Reactor; 2 High-pressure cylinder; 3 Low-pressure cylinder; 4 Condenser; 5 Deaerator; 6 High-pressure circulating pump; 7 Condensate pump; 8 Low-pressure reheaters; 9 Turbine separator; 10 High-pressure reheaters; 11 High-pressure feed pump; 12 Medium-pressure reheaters; 13 Medium-pressure feed pump; 14 Medium-pressure steam generator; 15 Steam generator steam-washing device; 16 Reactor blowdown; 17 Steam generator blowdown; 18 General station blowdown; 19 Total make-up

the half-life of which is also small. Such a filter therefore will not require any special maintenance conditions.

Steam Generator Position

Direct-cycle nuclear power station layouts (1*a* and 1*b*) designed for boiling water reactors without a steam generator are shown in Figs. 1*a* and 1*b*, protection of the reactor from contamination of its water by impurities penetrating with cooling water leakage is used in both layouts; and in layout 1*b* the reactor is also protected from the products of all pre-reactor line corrosion. The single circuit layout without protection from major sources of impurity entering the system is not given, since it is of no use in view of the above mentioned considerations for full-scale nuclear power stations operating over long periods. However, this layout can be produced readily from layout 1*a* by eliminating the heat exchanger (19) and pumps (22) or from layout 1*b* by eliminating the equipment (23) and (24).

An additional heat exchanger (19) can be included in layout 1*a* when the post-turbine pressure chosen is slightly higher than usual. For instance, at the Dresden power station (U.S.A.), the condenser pressure is raised to 0.08 atm. instead of the usual 0.04 atm. as a result of which the necessary temperature difference between cooling water in the condenser (5) and the heat exchanger (19) is achieved. In respect of cost and space, however, this solution is more expensive than an ion-exchanger installation, which is preferable from the Soviet point of view.

Reactor Protection

A second problem of at least equal importance is reactor protection against the penetration of corrosion products from all power station equipment (which is mostly made of carbon steels); this can be solved only by the arrangement just before the reactor of filters working at full pressure and, most important, at sufficiently high temperatures and velocities. In these conditions an arrangement of ion-exchange filters seems to be eliminated at present and probably in the near future since the ion-exchange resins available allow operation at temperatures of about 40°C., and only some of these and, of course, the most expensive ones operate at temperatures from 90° to 100°C., *i.e.*, at temperatures occurring before the deaerator and even before the low-pressure reheater. Nevertheless, the scheme shown in Fig. 1*b* is promising and the best from the Soviet point of view with respect to reliability of water conditions and to reduction of equipment costs. In this scheme the reactor pressure is equal approximately to that before the turbine, which reduces the costs of pressure vessel and tubings, and the steam generator, which is a sufficiently expensive element by itself, is eliminated together with its tubing system.

Separate Generator

It still seems expedient to use the indirect-cycle scheme with a separate steam generator since the realization of the scheme in Fig. 1*b* with a filter (24) before the reactor is impossible today, especially for power stations with high and very high pressures. However, this is far from unimportant both from the standpoint of water conditions and from that of equipment costs in whatever part of the indirect-cycle layout the steam generator is included and whatever its purpose and utilization may be in the overall power station scheme.

An indirect-cycle nuclear power station layout (1*c*), with boiling water reactor is given in Fig. 1*c*, in which the steam produced in the reactor serves as primary coolant. The disadvantages of such positioning of the steam generator are as follows: (i) reactor pressure must be higher than that before the turbine and as a result pressure vessel weight and cost increase; (ii) steam generator heating surfaces made of austenitic stainless steels work at high temperatures and at fairly large pressure variations. This creates a real danger of stress corrosion for these steels in the presence of Cl-ion and necessitates demineralization of make-up secondary loop water even under average pressures; (iii) fairly considerable quantities of stainless steel are needed for heated steam generator surfaces due to operation at medium and high pressures.

Low Pressure Area

It seems to be more rational to transfer the steam generator into a low pressure area, for example into the position of a turbine separator (*see* Fig. 1*d*). In this case the reactor pressure may be reduced to the value of the initial turbine pressure or by keeping reactor pressure at the same level as for layout 1*c* no pressure before the turbine may be raised and electrical output increased.

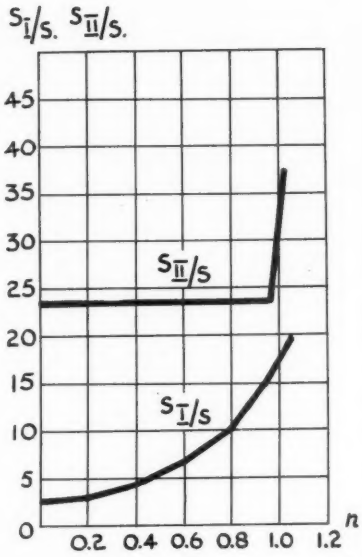


Fig. 3.—Relative concentrations of corrosion products and salts in reactor water and in steam generator water depending on portion of feed water entering directly into the steam generator

$$n = \frac{D_w^{II}}{D_{II}}$$

In layout 1*d* shown in Fig. 1*d* the steam generator heating surfaces made of stainless steel work under low pressures. Smaller pressure ranges correspond to the given temperature range for tube walls in low pressure areas; this is in accordance with the thermodynamic properties of steam. At a reactor pressure equal to 70 atm., the pressure range is 1·7 atm. for layout 1*c* and only 1.3 atm. for layout 1*d*. This in conjunction with the low steam temperatures for layout 1*d* eliminates all possibility of stress corrosion in the presence of Cl-ion, which allows the preparation of make-up secondary loop water by the H-Na-cation exchange method. Because of smaller wall thickness for the steam generator with a given heating surface, the heat transfer coefficient and temperature range may be adapted the same as for layout 1*c*. Smaller quantities of austenitic steel are required for layout 1*d*.

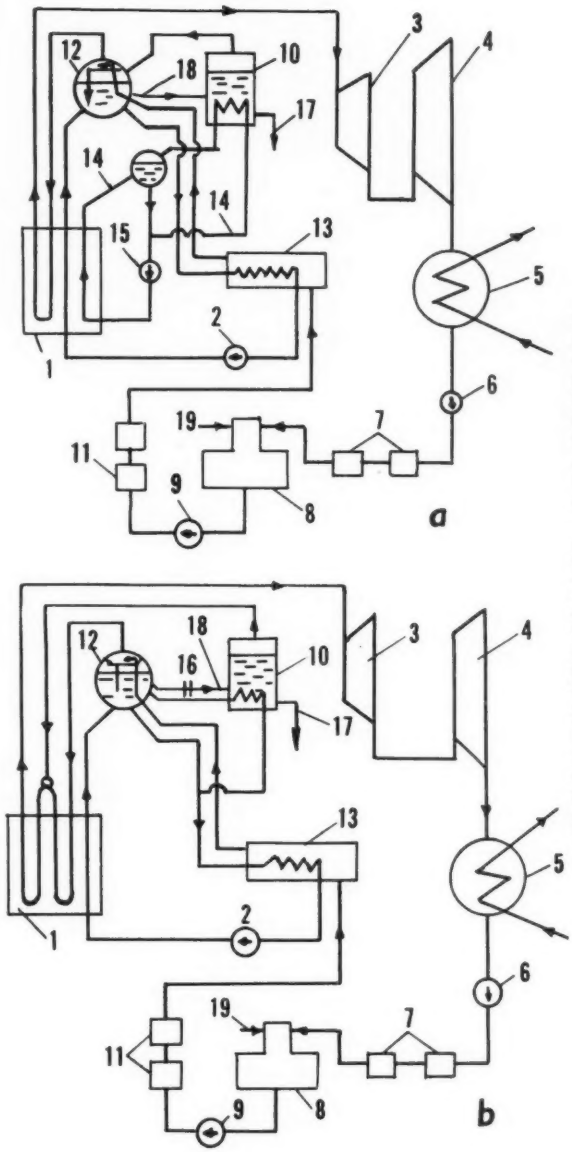


Fig. 4.–Nuclear power station direct-cycle schemes with high pressure saturated steam as a coolant, high parameters turbine, reactor steam superheating and with high pressure steam generator of a low output

Key: 1 Reactor; 2 Basic reactor circulating pump; 3 High pressure cylinder; 4 Low pressure cylinder; 5 Condenser; 6 Condensate pump; 7 Low pressure reheaters; 8 Deaerator; 9 Feed pump; 10 High pressure steam generator of small output; (second step of evaporation); 11 High pressure reheaters; 12 Separator drum of high pressure; 13 Water economizer; 14 Very high pressure loop; 15 Small circulating pump of very high pressure circuit; 16 Throttle; 17 Overall blowdown; 18 Reactor blowdown—feeding for second evaporation step; 19 Overall make-up

Layout 1*d* may be used for high pressure nuclear power stations with steam superheating in the reactor, including those with very high and above-critical parameters. Placing steam generators between the turbines eliminates the need for a turbine separator, and the steam drainage carried out by the low pressure steam generator before the low pressure stage enables intermediate steam superheating to be avoided without the danger of increasing the moisture constant of the steam in the turbine end even at very high parameters. Comparison of layouts 1*c* and 1*d* shows convincingly that steam generator disposition in an indirect-cycle nuclear power station layout is important both from the standpoint of costs and from that of water condition reliability. Examinations of the thermal layout 1*d* have been carried out recently by the Department for Nuclear Power Stations at the Moscow Institute of Energetics, to determine the most rational position for the steam generator under reactor pressures of 32-140 atm. It was found that the optimum pressure for the steam generator in the layout 1*d* is about 2 atm. The examination of layout 1*d* consisted mainly of comparing it with layouts 1*a* and 1*b* since by shifting the steam generator into a high pressure area, layout 1*d* is converted into 1*a* and by shifting it into a lower pressure area, into layout 1*b* (or 1*a*).

Indirect Cycle

From the Soviet standpoint the suggested indirect-cycle layout 1*d* has considerable advantages over the direct-cycle ones. It should be remembered that not all equipment is active in indirect-cycle power station layouts and if this facilitates operation considerably and can be achieved for a reasonable increase in cost of the power station, it should not be neglected. Moreover, in comparison with layouts 1*a* and 1*b* the pressure vessel construction in the indirect-cycle layout is simplified by the preturbine pressure given, the value of the reactor blowdown is reduced, special water treatment costs are reduced and water preparation is simplified; these results compensate to some extent for the steam generator positioning costs. In the layouts described above with a steam generator, the purpose of the latter is simply to separate the primary and the secondary loops, active as well as inactive. However, another use for the steam generator is possible. One efficient use of steam generators at direct-cycle stations is shown in Fig. 2*a*; this provides additional steam output for the turbine at the expense of cooling the reactor water. This in turn allows a reduction of the steam in the reactor with a given power station electrical capacity, which is favourable from the point of view of reactor physical characteristics; it also simplifies the power station control system. However, if a steam generator is included in a nuclear power station design, in accordance with these considerations, it ought to be used also to improve the water conditions of the installation. This may be achieved by regarding the reactor and steam generator of Fig. 2 as an indivisible steam-generating installation and by using the step vaporization method which is widely used at thermal plants in the Soviet Union.

The feeding of reactor and steam generator, in which a second evaporation step takes place, is thus achieved for the water entering the reactor. The reactor blowdown increase which may be made equal to the steam generator output, leads to a

reduction in salt and corrosion product concentration in the reactor water. In the steam generator a higher concentration of these substances can be tolerated. The guaranteed reactor water purity is the major advantage of such control of water conditions. Impurity concentration in this layout may vary within wide limits (*see* Fig. 3). It is necessary to note, however, that the steam generator in the Fig. 2 type layout is very large and its use is far from universally recognized.

Superheating

When nuclear superheating is used all steam going to the turbine can be produced in the reactor using layouts similar to those in Fig. 1. The high purity of reactor water needed can be obtained only by huge reactor blowdowns which are uneconomical. If the reactor blowdown is reduced to acceptable values, impurity concentrations will increase too much, which leads to scale formation on the fuel elements.

By means of stepped evaporation a steam-generating installation might be created which would consist mainly of a reactor but would have a second part with a low output designed to ensure much smaller heat loads and allowing phosphate treatment. A low output steam generator extended beyond the reactor must serve as this second part. The rough layout for using a steam generator in this way in a power station with nuclear superheating is shown in Fig. 4. If steam from a low output steam generator has to be produced under the same pressure as the basic reactor steam, steam (or water) under higher pressure must be used as the generator coolant. Thus an additional circuit of water (or steam-water) channels is required (*see* Fig. 4*a*) with a heat output not exceeding 5-7 per cent. that of the reactor. Nevertheless the presence of this circuit allows the concentrations of scale-forming salts to be maintained at an acceptable level without using phosphate treatment for the water going to the reactor, *i.e.*, to provide scaleless and flockless water conditions in the reactor. The concentrations of corrosion products in the reactor are also known to be low. Other positions for the steam generator are possible, *e.g.*, as shown in Fig. 4*b*.

Steam Washing

While developing the thermal layout and steam generator design, it is expedient in all cases to use a steam washing method, using it not only to improve steam purity, but also as a means of steam disactivation (removal of active impurities) and completion of air-removal for feed water, so that the water which cools the heating surfaces is completely free from oxygen. Thus, washing equipment will perform the function which in normal boilers is carried out in the liquid space of the drum, *i.e.*, in a zone of absence of metal heating surfaces subjected to corrosion that is always redoubled when oxygen is present.

Conclusions

1. At nuclear power stations with boiling water reactors an indirect-cycle layout with a steam generator before the low pressure turbine cylinder can be used to provide the required water conditions. Meanwhile steam from the reactor goes directly to the high pressure turbine.

2. In direct-cycle nuclear power stations with boiling water reactors where steam generators are used to increase electrical output without increasing steam content in the core, the reactor and steam generator should be regarded as an indivisible steam-generating installation, employing stepped evaporation to reduce the concentration of corrosion products and impurities dissolved in the reactor water.

3. The use of stepped evaporation at nuclear power stations with boiling water reactors ensures reliable water conditions for the reactor installations. For this, there must be two zones with a different concentration of corrosion products and impurities dissolved in the boiling water; these are a low concentration zone in the reactor, where most of the steam is produced, and an elevated concentration zone to produce the rest outside the reactor, this requires the inclusion in the power station design of a low-output steam generator equal to the necessary reactor blowdown.

4. Complete elimination of steam generators in nuclear power stations with steam-water coolant will only be possible after the manufacture of a reliable and cheap filter, suitable for working in a high temperature and pressure range, and at high velocities.

A.E.R.E. Monographs received

On the Determination of Magnetic Fields in Slabs and Cylinders by the Measurement of the Time of Flight for Displacement of Monoenergetic Ions which are Projected Away from the Wall and returned by the Magnetic Field, by R. T. P. Whipple. Published by Theoretical Physics Division, AERE, Harwell. Reference AERE-R3486. Available from H.M. Stationery Office. Price 9*s*.

A Vacuum Ultra-violet Radiation Source of High Intensity. Part I: Survey of Sources, Window Materials and Methods of Dosimetry, by F. S. Feates, B. Knight and E. W. T. Richards. Published by Chemistry Division, AERE, Harwell. Reference AERE-R3426. Available from H.M. Stationery Office. Price 2*s*. 6*d*.

A Survey of the Plutonium Spectra in the 7,000-10,000 Å Region, by L. Bovey, M. C. J. Barker and A. Ridgeley. Published by Chemistry Division, AERE, Harwell. Reference AERE-R3515. Available from H.M. Stationery Office. Price 2*s*. 6*d*.

Transistors in Experimental Work, by F. M. Russell. Published by Accelerator Division, AERE, Harwell. Reference AERE-M650. Available from H.M. Stationery Office. Price 6*s*.

Lectures on the Hydromagnetic Stability of a Cylindrical Plasma. Part 7: The Role of Compressibility, by R. J. Taylor. Published by Theoretical Physics Division, AERE, Harwell. Reference AERE-L108. Available from H.M. Stationery Office. Price 2*s*. 6*d*.

Exact Solutions for the Adiabatic Collapse and Forced Radial Pulsations of a Plasma Cylinder containing a Magnetic Field, by R. J. Taylor. Published by Theoretical Physics Division, AERE, Harwell. Reference AERE-M548. Available from H.M. Stationery Office. Price 3*s*.

The Measurement of Fast Neutron Flux Using the $S^{32}(n,p)P^{32}$ Reaction, by B. H. Parker. Published by Reactor Division, AERE, Harwell. Reference AERE-R3443. Available from H.M. Stationery Office. Price 5*s*. 6*d*.

A Low Energy Beta Probe, by K. E. G. Perry and R. A. Bishop. Published by Electronics Division, AERE, Harwell. Reference AERE-M771. Available from H.M. Stationery Office. Price 3*s*.

Design and operation of the radiochemistry laboratory

by G. R. Hall, Imperial College, London

Part II

IN Part I some general design features were discussed and layout philosophy was considered in relation to both the large group of laboratories or a smaller radiochemical unit. Attention has been drawn to the necessity for providing adequate ventilation and suitable effluent control. These two factors will now be considered in more detail.

Ventilation

The ventilation plant, including plenum and extract ducting, must be capable of confining, controlling, collecting, or dispersing any radioactive airborne contaminants, be they solid or gaseous. Control through ventilation presents many unusual problems to the engineer. For example, efficient filtration may be necessary, radioactive contamination of ducting may occur, air flows must always be from low level to high level active areas and must never be reversed (hence no recycling allowed), there are usually large numbers of air changes in the laboratories. The latter is most important to the designer of large or small laboratories.

Thus the ventilation engineer will normally expect the number of air changes/room to be specified for him. Whilst values of 10-20 changes/hr are suitable for most purposes, in practice, the rate of air change is often greater and depends mainly on the number of fumehoods in the laboratory. Thus in the normal radiochemistry laboratory all ventilation air is extracted through the fumehoods (Fig. 5) and it is usual to require air flows of 100-200 ft/min across the face of the fumehood to protect the worker from possible back flow of radioactive dust or gas.

Calculation of Air Changes

Assume that the laboratory is 600 sq.ft × 10 ft ceiling height and there are 10 fumehoods each with a 3 ft wide window, open 1 ft on average. Then total volume of air extracted $= (3 \times 1) \times 10 \times 200$

$= 6{,}000$ cu.ft/min

$$\therefore \text{ Air changes} = \frac{6{,}000 \times 60}{600 \times 10} = 60/\text{hr}$$

Such calculations will show that it is more economical to provide laboratories with a low ratio of fumehoods to total room volume, and that large laboratories tend relatively to be easier and cheaper to ventilate than small ones. On the other hand, on grounds of personal preference or to restrict spread of cross-contamination, small laboratories may be preferred. The number of fumehoods therefore tends to define the number of air changes/laboratory, influences the size of the ducting and fans and also the running costs—particularly important when air has to be heated or cooled.

Fumehood Design

There is a great need for a suitable design of fumehood which is safe but which does not require such high flow rates of conditioned air. There have been suggestions that by-pass air might be fed to the face of the hood, and then only small volumes of conditioned air would be used, although the overall flow across the fumehood face would still be as great. Hoods of this type have been developed in the U.S.A., but are not apparently used in this country.

In the case of Class *A*, and often class *B* laboratories, adequate extraction filtration must be provided. Electrostatic precipitrons have been used on the large laboratory installations but present tendency, for both large and small laboratories, is to use solid disposable filters—the Vokes K600 Composite Kompak is adequate for many purposes and removes solid particles down to a size of a few microns, whilst, where there is a special danger of airborne contamination on very small dust particles, an absolute paper-type filter is used. These filters will not remove radioactive gases, however, and hence to remove say iodine-131 either scrubbing or special adsorption units are required.

No matter what level of activity is to be handled, it is always advisable to release laboratory extracted air at least at roof level. If extensive contamination of the extracted air is likely, then the air should be released at a suitable height, above ground level, through a chimney. In this country the released air is usually at a temperature greater than atmospheric and so the rate of dispersion and mixing is increased. In the author's laboratory in Bombay, however, the extracted air was released to the atmosphere at a temperature sometimes 25°F. below ambient—the air in the laboratory being cooled to 78°F. to maintain comfort conditions. In this case, use of an absolute paper filter removed all activity and no contamination was detected outside the laboratory at ground level.

Fig. 5.—Pipetting a radioactive solution in a fumehood

Effluent

Effluent control is usually essential in a Class *A* laboratory, whereas in a Class *C* laboratory normal laboratory water services and sinks are used and, indeed, appreciable amounts of radioactive wastes[5,6] can be allowed in the sink.

Activity can get into the drains, not only by direct spillage, but by contamination from equipment or from a cooling water supply from a cracked condenser. It is for such reasons that all drainage in a Class *A* laboratory is usually fed to delay tanks. Here, the waste liquids can be monitored for their activity level prior to disposal through the drains —or, if the activity is too high, they can be diluted or treated. Thus active drainage, in its simpler form, can lead to a series of two or three delay tanks together with a pump, pipe and valve layout in which such operations as mixing, drip sampling, dilution or pumping to drains can be carried out.

It is important to restrict use of water, especially for cooling purposes, in the Class *A* laboratory in order to reduce the problem of effluent handling. In the larger laboratories the cost of handling and treating effluent can be very high and it is worthwhile using recirculating cooling water units or recirculating water pump units despite the initial capital cost. Spence[3] has found that water consumption has decreased from 400 gal/man/day to 115 gal/man/day after introduction of portable cooling water units and reduced usage of straight-through process water in the radiochemistry laboratories at Harwell.

No comment has yet been made on disposal of radioactive solid and more highly radioactive liquid waste arising in the laboratory. This is partly a problem for the Health Physicist. It is usual to provide foot-operated bins for solid waste (Fig. 6) and it may be useful to separate combustible from non-combustible wastes. This is important at Harwell, where closed incinerators are used to burn the combustible wastes collected from laboratories. The PVC bag technique (Fig. 7) is of great value in removing waste from glove boxes.

Liquid concentrated wastes from experiments are usually stored in carboys, and it is advisable to separate organic liquids from aqueous acid wastes. It is also good practice regularly to neutralize the acid wastes. In order to reduce the volumes of liquid waste for ultimate disposal, it is often necessary either to recover radioactive materials or at least to concentrate them by precipitation.

The Health Physicist should keep a record of all radioactive materials in the laboratory, and an estimate of all outgoing activity whether in liquid or solid effluent *e.g.*, assay of the delay tanks should be a routine operation.

Fig. 6.—The chemist monitors a contaminated tissue before disposing of it in the foot-operated waste bin

Active Store Room

In small radiochemical laboratories active sources are often stored in the laboratory either in their transport container or behind lead brick shielding in a fumehood. In the larger group of laboratories it is advisable to have a room designed for source storage. It should have adequate internal shielding for the levels of activity to be stored in it and should also be ventilated.

It is not unusual to store radioactive liquids in sealed containers. As 5 mc of α-activity or 50 mc of β-activity will produce at least 1 cu. cm of gas at NTP per month due to radiation decomposition of water, it is important to vent such containers.

Laboratory Furnishings

As we have seen, all engineering services for the radiochemistry laboratory are designed to minimize the dangers from possible spread of radioactive contamination, and, for the same reasons, careful consideration should be given to furnishings. The following comments apply broadly to Class *A*, *B*, and *C* laboratories.

Undoubtedly the most satisfactory floor covering is linoleum which has been given a wax polish to maintain a waterproof surface. Care should be taken to ensure joints are away from possible sources of contamination—such as the sink.

Walls should preferably be plastered but fair-faced brickwork may be acceptable. Both walls and ceiling should be painted with a good hard gloss enamel paint and a chemical resistant paint used where contamination is likely to occur. In Class *A* and *B* laboratories it is essential to reduce to a minimum all dust collecting surfaces—hence all piping and conduits should either be concealed by plaster or boxed in.

Sinks often lead to spread of contamination. A stainless steel sink and drainer is perhaps the most satisfactory type, but a good quality glazed porcelain sink is much cheaper and adequate providing (*a*) it is not or does not become chipped or cracked or (*b*) it is not mounted in a wooden surround which provides cracks or ledges for harbouring activity.

Furniture

Most types of laboratory furniture are suitable, providing no bare wooden surfaces are visible, and that surfaces may readily be decontaminated. In the author's opinion, hard gloss enamel painted wooden surfaces are much preferable to a stained finish. Stainless steel work tops are good but very expensive, whilst "formica-type" bench surfaces are becoming popular and are very satisfactory providing care is taken to seal the edges.

Ventilation of all fumehoods has been considered but equal care should be given to their design. Typical hoods have floor dimensions of 3 ft × 2 ft and are designed to withstand loadings of at least 500 lb/sq.ft where lead brick shielding is to be installed. Interior surfaces should be painted with a chemical resistant paint—at Harwell a rubber-based strippable paint is used. Care should be taken about drainage from fumehoods, if provided, especially as in Class *A* laboratories high levels of contamination are to be expected. All services *e.g.*, lights, electricity connections, gas, water, etc., should be operable from outside the fumehood. It is also useful to

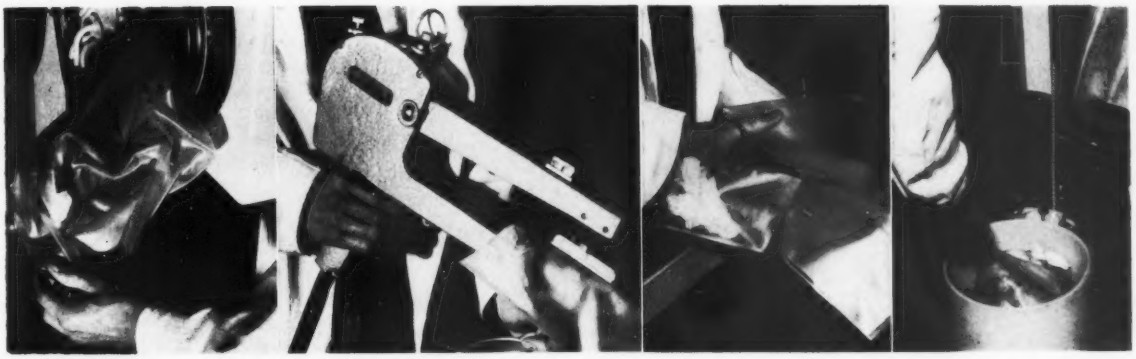


Fig. 7.—Sealed PVC bag disposal technique
(*Left*) Waste material is pushed through a glove box port and into a PVC bag hanging outside the box
(*Top, left to right*) Waste is pushed to the bottom of the PVC bag; the end of the PVC bag is sealed with a high frequency tong welding unit; the welded end portion of the PVC bag is removed by cutting along the welded seams; the waste, now sealed in a small PVC bag, is disposed of in a waste bin

have interconnecting windows between adjacent hoods.

Laboratory Management

In a large building containing several radiochemistry laboratories it is quite possible that the members of supporting staff, *e.g.*, maintenance engineers (for ventilation, effluent and workshops), cleaners, electronics and health physics staff, etc., may outnumber the scientific staff for whom the building was provided. All play an important part in the successful running of the building but their general administration can present many problems. This is particularly so where the Health Physicist is concerned. He is usually expected to *advise* not to command and in order to accomplish his many duties he requires both extensive experience in the many problems of health physics and also great tact.

In addition, the good Health Physicist, apart from understanding the problems of control and safety, will often also be able to advise on experimental techniques.

In the smaller unit, perhaps only one or two laboratories, it is usual to nominate someone who is experienced in handling radioactive materials to act as health physics safety officer. One of his first duties will be to formulate a code of behaviour which will provide advice on many aspects of radioactive work[5]. Health Physics regulations have been discussed by Gould[1] but reference will be made here only to emergency procedures in cases involving accidents with radioactive materials. Such an accident may be due to fire or to apparatus or operational failure and can lead to serious consequences. The procedure to be taken in a serious accident might include the following:

(*a*) evacuation of all persons from the laboratory. They must be monitored, however, as soon as possible to prevent further spread of contamination.

(*b*) only the minimum qualified persons in protective clothing reenter for remedial action.

(*c*) set up contamination control point outside area of accident and area of contamination.

(*d*) it may be necessary to close down ventilation in the laboratory and switch off other services.

(*e*) decontamination of whole area.

Each of these items is of direct concern to the laboratory designer. Thus he must ensure good evacuation escape routes and sufficient emergency " crash " doors, an alarm warning system, sufficient fire extinguishers (usually carbon dioxide type are preferred) and also local controls for the ventilation plenum and extract ducting for each laboratory.

This list is not exhaustive but serves to show once more how the designer must be able to envisage the final operation and management of the laboratory and be able to incorporate those improvements which serve to make the laboratory both satisfactory and safe for the laboratory scientific worker. In conclusion it cannot be stressed too strongly that the designer and the scientist should get together at the earliest possible stage in the design of the laboratory and its associated facilities.

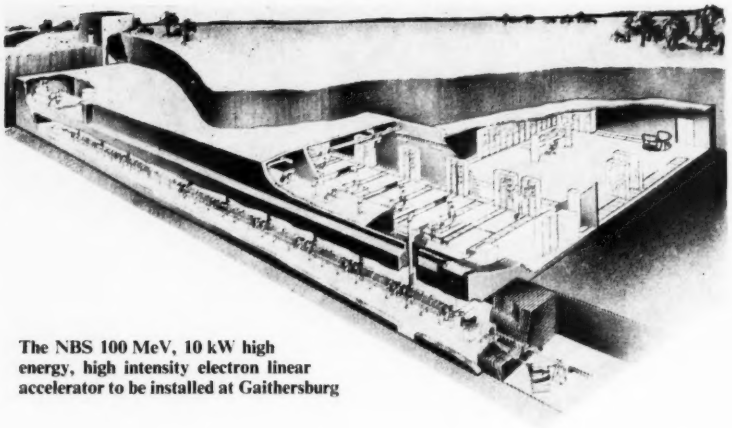
References

[1]DISMUKE, S. E., Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955, **7**, 67-81.

[5]Code of Practice against Radiation Hazards, Imperial College, 1960.

[6]DUNSTER, H. J. *Medicine Illustrated*, 1954, **8**, 1-15.

[7]HALL, G. R. Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, 1958, **17**, 691-695.



The NBS 100 MeV, 10 kW high energy, high intensity electron linear accelerator to be installed at Gaithersburg

AMERICA'S RECORD ATOM-SMASHER

by F. R. Paulsen, BSc, PhD, FRIC, FCS, MINucE
(Member of Council)

WELL over 300 scientists and engineers from 24 countries met in Amsterdam in October, 1960, for a three-day scientific conference on the development and applications of radiation-producing particle accelerators in nuclear physics, particle research, radiation research and industrial processing. Besides listening to 22 papers on various aspects of these many fields, the participators toured the new High Voltage Engineering (Europa) plant at Amersfoort, where four Van de Graaf accelerators, including one of the tandem type, are being assembled and tested.

This conference, which Denis M. Robinson, President of High Voltage Engineering Corporation, U.S.A. described as a "highly successful exchange of ideas and scientific techniques from which both the designers and the users of radiation machines are certain to profit," was sponsored by the HVE Corporation. This firm is one of the most experienced concerns in the world undertaking the design and construction of accelerators. For this reason, then, the Corporation was approached when the question arose of providing the world's most intense precision source of ionizing electron beam radiation, a microwave linear electron accelerator or Linac to be installed at the National Bureau of Standards in the U.S.A.

This accelerator, costing over $1.7m., was designed to the specifications laid down by NBS scientists. The magnitude of the project will be realised when it is stated that the power output of this machine will be over 100,000 times greater than that obtained from existing NBS high energy accelerating machines, which include a 50 MeV betatron and a 180 MeV synchrotron.

Since the National Bureau of Standards accepts the responsibility for the natural standards of physical measurements, it has to provide the basic data, standards, and measurement technique required in the branch of radiation physics involving high energy electron beams. Industry has already started to use such beams for the sterilization of foodstuffs and pharmaceutical preparations, for the polymerization of plastics and for rubber vulcanization.

The new accelerator will be installed at the new NBS laboratories at Gaithersburg, Maryland. It will produce electron beams with energies continuously variable from 10 to more than 40MeV, and provide power outputs above 40kW. This will make possible the attack on new fields of nuclear and atomic physics, and will also facilitate studies of polymerization, and the shielding requirements for the very high dose rates which are being used increasingly in industrial processes.

Wide Range

There is, of course, a definite philosophy behind the purchase of this very challenging accelerator. The Bureau of Standards, responsible for overseeing the general national applications of radiations, wants a machine which will duplicate as many radiation conditions as possible. The Linac will make possible a wide range of energy and current, so that the NBS will anticipate a great many radiation processing situations and will be able to explore the effects for standardization purposes. In addition, a first class basic physics research programme will become possible.

The NBS Linac is basically a 100 ft long straight tube through which electrons are accelerated upon the crest of a travelling microwave. There have been immense steps forward in microwave electron linear accelerators of recent years, making possible more power, greater precision, and increased versatility. In the new machine the waveguide consists of nine sections, each 8½ ft long, supplied with RF power at an L-band frequency of 1,300Mc. The first three sections are powered by 10 MW-peak amplifiers, the last six by 5 MW-peak amplifiers. The power sources may be either klystrons or amplitrons, the latter being strongly favoured, since they offer high efficiency, stability, simplicity, and economy. The final choice, however, will depend on the results of testing. The electron beam

current will attain peak values of the order of 0.25 amp or more/pulse, or about 0.5 ma time average. Beam pulse duration will be variable from 0.1 to 6 microsec. The electron beam power will exceed 40 kW at 100 MeV beam energy.

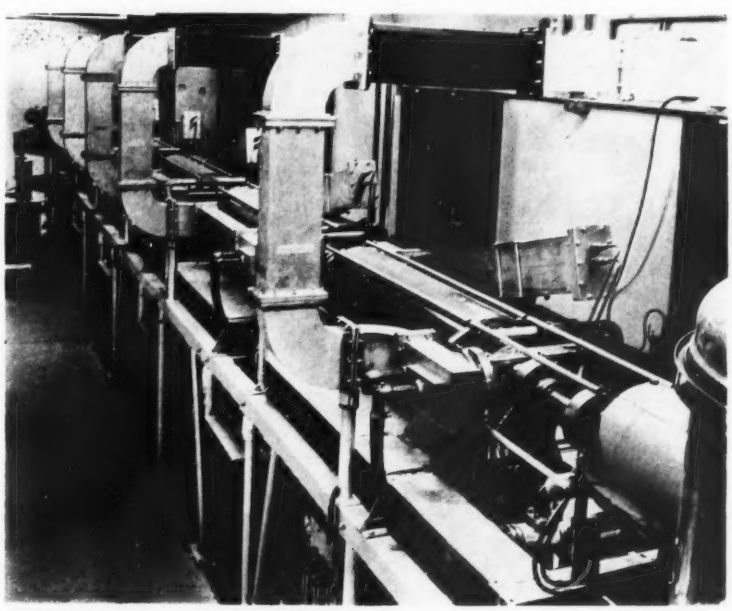
The ejected electron beam will be controllable by magnetic fields, and made to interact with various target materials, or the beam will be directed at certain targets in order to generate beams of X-rays, positrons, or neutrons. These in turn will be used for research and materials testing. The emerging beam will be less than 2 cm in diameter and very stable in position, intensity and energy over long periods. It may be possible that a magnet system can shift the electron beam from one well-shielded experimental area to another, thus saving much time in setting-up apparatus when experiments have to be changed. A summary of the important parameters is as follows: nominal energy 102 MeV maximum energy 150 MeV, peak pulse current 242 ma, maximum beam power 40 kW, beam pulse length range 0.1 to 6 microsec, PRF range 7.5 to 1,000 pps, L frequency band, power tube ratings 5 MW peak, average 10 kW, nine sections, accelerator tube length 22.5 meters

Model of new NBS research facilities at Gaithersburg, Maryland. The microwave linear accelerator will be installed as part of the Radiation Physics Laboratory which can be seen in the bottom left-hand corner

The record performance of the NBS accelerator is due partly to a recent technical achievement in accelerator wave-guide design by engineers of High Voltage Engineering Corporation and the affiliated Applied Radiation Corporation. This " High-Q " design, incorporated into the wave-guides, makes use of a new resonant structure resulting in higher power efficiency of conversion of microwave power to electron beam power, and greater beam currents and pulse length. This concept has already been tested on two accelerators—at High Voltage Engineering, in Burlington, Massachusetts, and at Applied Radiation Corporation, Walnut Creek, California, and it will be incorporated in four commercial machines now being constructed.

There were four companies competing for the construction of the NBS giant accelerator, but High Voltage, with its 12 years of experience in the field and the reputation of having built more than 250 radiation-producing machines, won the contract. The accelerator is likely to be installed late in 1962. Prior to delivery, the sections will be tested in the 100 ft radiation-proof vault at Walnut Creek.

Microwave linear accelerator for Lawrence Radiation Laboratory on test in the Applied Radiation Corporation facility



N.B.S. Site

At Gaithersburg, 20 miles northwest of Washington, D.C., the NBS site offers a 550 acre area, the size and topography of which will make possible four time-of-flight tubes, 100, 200, 300, and 800 metres in length respectively. These will be used to measure neutron cross-sections and energy spectra of photoneutrons. The new high-energy Linac will be installed below ground level, making use of the inexpensive radiation shielding of earth. Individual radiation laboratories will be shielded from each other by concrete walls up to 12 ft in thickness.

The Linac will serve as an experimental tool in research programmes in low temperature chemistry, solid state physics, metallurgical studies, activation analysis for trace elements, nuclear alignment work, and the determination of properties

of irradiated materials. Other fields, such as nuclear reactor design and industrial radiation technology will also be enhanced through the Linac work. It will assist in the sterilization of pharmaceuticals and foods, the polymerization of plastics, and vulcanization of rubber, which are of extreme importance to industry.

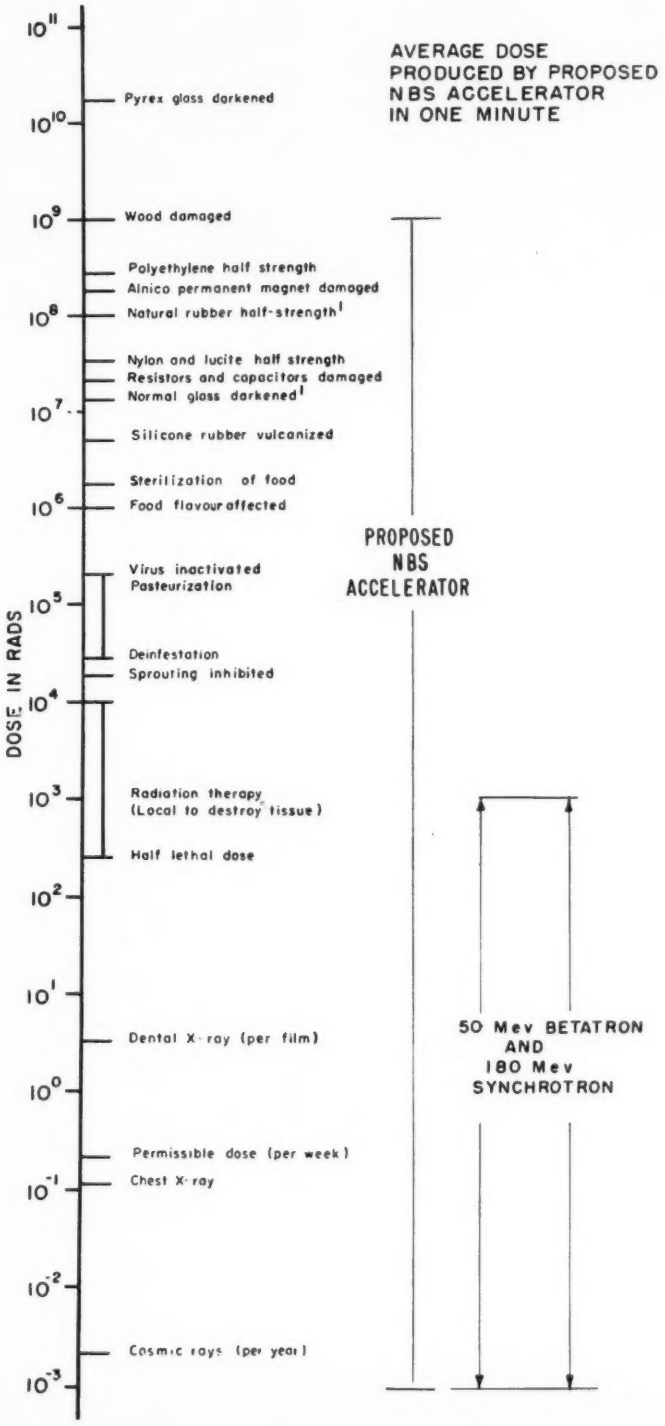
Radiations Available

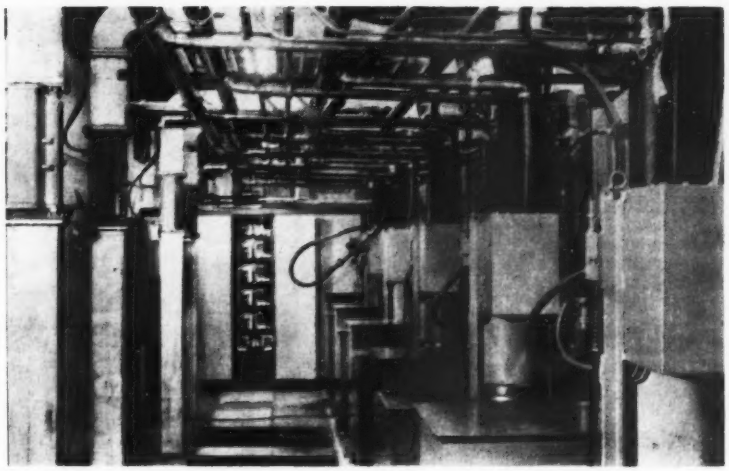
The radiations available for experimental work will be as follows: Electrons will be available as a 0.5 ma average current at peak currents above 0.25a, and with energies continuously variable from 10 MeV to over 100 MeV, and giving doses up to 1,000m. rads/min. It will be possible to produce X-rays of the Bremsstrahlung type with a continuously variable upper energy peak in the spectrum over the same range as that possible with electrons. The beam power through a surface of 1 sq.cm, 1 m from the target will exceed 200w. By absorbing the electrons in suitable targets, intense neutron fluxes will be obtained, generated in bursts which are ideal for time-of-flight work.

Based on a peak electron current of 0.25a and time average current at 0.5ma, neutron yields of 1m./sec or 10^{13} neutron/sec time average will be possible. Using radiators of high atomic weight, it will be possible to generate, via the incident electron beam, positrons which will be collected and analysed in a magnetic system to produce a source of monoenergetic photons when undergoing annihilation during flight through a lithium hydride target. The positron beam will produce about 1m. photons/sec in a 1 per cent energy bin, these photons being 0.75 MeV above the end of a Bremsstrahlung spectrum produced by those positrons which radiate when passing through the foil. The number of annihilation positrons will be about 30 times that of the photons in the top 10 per cent of the Bremsstrahlung background.

None of these radiations are produced in sufficient quantities by the betatron and synchrotron for the purpose of work now projected. Experiments that previously took months of effort and exposure time when they were possible at all, will now be accomplished in a few hours.

Comparison of radiation doses available in one minute from present facilities at NBS and that from the new Linac





Modulator area in the Applied Radiation Corporation's test facility with L-band linear accelerator under construction for Yale University

For example, it will be possible to measure the polarization in the nuclear photo-effect, and this should provide invaluable information about nuclear wave functions.

Studies in dosimetry will be extended enormously. Existing dosimetric standards are based on absorbed doses of hundreds of rads, and dose rates of tens of thousands of rads/hr. There is a pressing need for additional standards for nuclear physics, personnel protection and health physics, solid state work, and industrial investigations. Such demands cover standards from 100,000 to 10m. rads, and in the future, dosimetry will be required for standards up to 10,000m. rads. The new Linac will provide 100,000m. rads/hr, and this dose rate, added to those available from the existing cobalt, radium, X-ray and electron beam sources, will enable NBS to conduct dosimetry studies in all ranges anticipated in the foreseeable future. It is against this background that the importance of the new NBS Linac machine becomes obvious.

Trade Literature Received

Berry Wiggins & Co., Ltd., have produced with the co-operation of Borax Consolidated, Ltd., a range of boronated bitumen compounds. Of these, Kingsnorth Compound No. 2028 has already found commercial use as a biological shield in nuclear reactors. Their descriptive leaflet states, " Kingsnorth Compound No. 2028 contains a bitumen soluble boron compound which is free from problems associated with sedimentation. The presence of boron in combination with hydrogen in this new material will, when used at the recommended thicknesses, ensure complete attenuation and absorption of slow neutrons." A fuller description of the new material may be found in the leaflet " Bitumen Compounds in Reactor Shielding " published by the manufacturer.

From their experience gained in producing the conventional Boral sandwich the Research Division of High Duty Alloys, Ltd., Slough, have evolved a specialized technique for the production of new thermal neutron shielding materials which have vastly improved formability. These new materials, known as the hiduminium 400 series, consists of boron carbide (B_4C) of fine mesh size, evenly dispersed in a fully wrought aluminium matrix, clad on both sides with high purity aluminium. A method has been perfected by which the B_4C particles can be uniformly suspended throughout molten aluminium, followed by semi-continuous casting to a rolling slab which is then clad and rolled in the normal manner. Technical details and applications of this new improvement on conventional Boral may be seen in the company's brochure, entitled " Hiduminium 400."

" It is essential that the scientific instrument industry receives a steadily increasing flow of young men and women who will become its expert craftsmen in the industry's numerous interesting branches," say the Scientific Instrument Manufacturers' Association of Great Britain, which has published " Careers in the Scientific Instrument Industry," a well-illustrated summary of what a newcomer to the industry can expect to find and what his work and training may be like. This 20-page booklet illustrates many types of scientific instruments in action and skilled craftsmen, with assisting apprentices, constructing them. Some idea is given of the trades and processes covered by the industry, such as in the building of motorways and the combatting of disease. The final two pages contain a geographical directory of the 170 member firms in scientific instrument making.

A new publication by Henry Wiggin & Co., Ltd., is designed for the welder of dissimilar metals. It claims to have overcome the difficulties of having to match the filler metal with the higher alloy of the metals being joined. The publication explains with tables and illustrations how Inco-Weld "A" electrode and filler wire have been specially developed for joining dissimilar metals. The brochure, entitled " Inco-Weld 'A' Welding Electrode and Filler Wire " is obtainable from the company's publicity department.

The eighth technical bulletin on new products has been issued by Nuclear-Chicago Corporation of Illinois. Entitled " How to Compute Absorption and Backscattering of Beta Rays," the bulletin stresses the need to be able to compute the absorption and backscattering of radiation in, for example, the case of beta rays in typical probing or gauging applications in, say, a preliminary study of a nuclear method for solving a given industrial problem. The purpose of the bulletin is to outline a method of calculation as a first estimate in such cases.

Data sheets describing over 225 items of 20 basic types of standard woven wire mesh element-in-line filters are available from Aircraft Porous Media, Inc., a subsidiary of Pall Corporation, New York. Each of

the series of 20 sheets shows a cross-sectional view of the filter element and housing. Working pressure, temperature ranges, port sizes and other significant factors are listed for each type shown. The tabular information includes part number, port type and size, rated flow, pressure drop and particle removal ratings.

Head, Wrightson & Co., Ltd., of England and Arthur G. McKee & Co. of America have recently formed a new jointly-owned subsidiary called McKee Head Wrightson, Ltd. With description reduced to the barest minimum and a well selected and attractive series of photographs, the company illustrates in a new brochure its scope and versatility in the design, engineering and construction of petroleum refineries and chemical plants.

The Cambridge Microscan X-ray analyser is based upon an instrument designed by Dr. D. A. Melford and colleagues at the Tube Investments Research Laboratories in collaboration with Drs. V. E. Coslett and P. Duncumb, who were responsible for a prototype developed at the Cavendish Laboratory, Cambridge. A comprehensive booklet on their Microscan X-ray analyser has been published by the Cambridge Instrument Co. The instrument described incorporates a deflection system to control the electron-probe so that it can also be made to scan a maximum area of about $\frac{1}{2}$ mm square on the sample surface, so revealing the distribution of a chosen element over the region scanned. It has proved itself useful for investigating metallurgical and mineralogical problems in which the precise examination of microstructure is important. The booklet covers background information and construction and describes in detail the major components. Also covered are performance, applications, results, specification, and installation.

John Matthey & Co., Ltd., have revised their 1302 publication, "Electrical Contacts." This booklet is intended to help designers of electrical and electronic equipment to select suitable contact materials. Under the headings Electrical Conditions and Mechanical Conditions are discussed the general considerations affecting selection of material and design of contacts, with detailed information and data on the different types of contacts in the JMC Standard Contact ranges. Also included are sections on electrodeposited contact surfaces, light duty slip rings and brushes and contact springs. Copies of the booklet are available on request to the company's head office.

For some time past there has been an ever-increasing need by lecturers concerned with the teaching of metallurgy in educational establishments for a source of supply of micro-specimens of known composition and structure—so claim Metallurgical Services, who have decided to produce a collection of Annotated Metallographic Specimens comprising, at present, 139 individual specimens of various alloys, with notes of suitable methods of preparation. We have received a brief description of these sets now available, together with prices. Lecturers are offered at reasonable cost specimen sets of the particular alloys in which they are interested, or which they lack to complete their own range.

"The Harvey Team" is an introduction from G. A. Harvey & Co. (London), Ltd., to their activities, products and personnel, particularly the latter, whose photographs punctuate the entire booklet. The company's activities in the fields of heavy and light fabrication and sheet metal work are briefly illustrated and enquirers who have copies of this booklet should now be able to direct them to the appropriate individual.

We have received Imperial Aluminium Company's "Impalco" catalogues, Vol. 1—Standard, and Vol. 2—Selected, on their aluminium and aluminium alloy extrusions. In the latter a cut-away thumb selector facilitates easy reference to the component uses, which are illustrated by scale diagrams. Weights are also given. In Vol. 1 reference is made through the name of the component and dimensions and weights available are tabled. A leaflet is issued with these which illustrates by photograph a few of the aluminium components in use.

As an aid to fabricators who undertake machining operations, Henry Wiggin & Co., Ltd., have produced a booklet on the machining of their high nickel alloys. They state: "Machinability is a function of mechanical properties, and it is to be expected that materials with the combination of high strength and ductility, characteristic of these high-nickel alloys, should call for a machining procedure differing in detail from that applied to metals and alloys with lesser properties." It is the object of the publication to indicate these differences, and a preliminary table with some of their mechanical properties offers a general picture of relative machining characteristics before the greater detail of the following subject matter.

Liquid Tile is a material manufactured by Evershield, originally as a heavy duty resistant coating for architectural uses. The substance has been used to coat several areas in the Bradwell nuclear installation, as a protection against contamination. It is said to withstand 10^9 times a lethal dose of radiation and can be decontaminated with soap and water. Its compressive strength is over 10 ton/sq.in. A colour leaflet is available from the company which illustrates various uses for this substance.

The Lead Development Association have produced another leaflet on the applications of lead—"Lead pigments for primer paints for iron and steel." The chemical processes involved are examined, together with some applications, of three pigments, red lead, calcium plumbate and metallic lead pigments. The subject is dealt with non-technically.

We have received a brief leaflet on W. G. Pye's new "Power Pack" for general experimental work in laboratories (Cat. No. 8440). The unit incorporates some new ideas and features, which are described in the specification, and illustrated by photographs.

A new general chemicals catalogue has been issued by Albright & Wilson (Mfg.), Ltd. An insert section shows the way their products are used throughout British industry in the manufacture of a multitude of industrial and consumer goods. Close on 350 products are listed in the booklet, which is designed for ready reference in bold alphabetical form. The company's general chemical department handles all grades of chemicals including those of high purity for specialized industries. Its interests embrace the production and sale of phosphoric acid, organic phosphoric compounds, inorganic phosphates and the development of a fast growing range of industrial finishing processes.

A short guide to the drafting of specifications for rubber products has been published by the Federation of British Rubber and Allied Manufacturers,who state, "Rubber specifications present difficulties to the engineer, not only because the physical behaviour of rubbers differs so profoundly from that of metals and other engineering materials, but also because rubber technology has advanced so rapidly that it is difficult for even a specialist to keep abreast of the full range of modern developments. For some time now rubber manufacturers have been concerned at the number of specifications met with in everyday practice which are for one reason or another inadequate for their purpose and sometimes positively prejudicial." The guide compiled by the Specification Advisory Committee, set up to examine the problem as a first step towards rationalizing this confusion, gives advice on the kinds of test most useful for performance testing (by the user) and quality control testing (by the manufacturer) and on the dimensional tolerances appropriate to different kinds of rubber component. It recommends the use of British standards whenever these are available and suitable for the purpose required, and especially of standard tests as set forth in the various parts of BS.903. To facilitate the exchange of information between user and manufacturer, the guide is accompanied by a series of questionnaires indicating in detail for each different category of rubber product the information on function, properties and service conditions which will be needed for the drafting of an up-to-date practical and effective specification.

Gelman Instrument Co. have sent us a copy of their 32-page Manual No. 5, "Radiochemical Applications of the Membrane Filter," which gives information on the techniques useful in radiochemical applications with 25 references. The membrane filter is a micro-porous plastic with uniform micron-sized holes in it and can be used to filter all radioactive particles from fluid and gas streams. Particles filtered are retained on the surface of the filter from where they can be collected and very accurately measured because there is no self adsorption on the instrument.

Gamma radiography of the bronze door of Gniezno Cathedral

by Zbigniev Godlewski

IN Gniezno, the first historical capital of Poland, an archbishopric was founded in 1000 AD[1]. Gniezno was at that time well-known for the cult of St. Adalbert-Voytech. The life of this saint has been represented graphically by the bas-relief on the main door of the Cathedral at Gniezno. The door is cast in bronze and—according to art historians—is a distinguished specimen of the Roman style to the north of the Alps. The door is distinguished for the richness of ideas (18 figured scenes), exquisite decorations of borders and its high quality[2]. Art historians have proved that the door of the Gniezno Cathedral was made in the second half of the twelfth century, between 1170 and 1180, with the participation of certain sculptors from Lorraine, but probably in Poland.

The door consists of two wings of different size. The right wing is 3,230 mm in height and 830 mm in width; the left wing is 3,280 mm in height and 840 mm in width. The thickness of the door is from 15 to 25 mm, and in some places, on the outer ledge, it comes to about 50 mm. In size the door of the Gniezno Cathedral is similar to the doors at Aachen, Münster, Hildesheim or Augsburg. Each wing on the front side contains 9 figured scenes sculptured in low relief (Fig. 1) and embraced with rectangular quarters separated from one another by rectangular ledges.

The reverse side of the door (Fig. 2) has no sculptures but there are bolts on it. On this side one can see a fill on both wings of the door and a fill below the bolt on the right wing of the door. That fill was made in order to repair the door and cover the crack which appeared. On the right wing above the bolt, there is a place where the cracked part is fastened to the remaining part of the door by means of two flat-irons and screws. On that side of the door one can also see traces of solderings. Those traces on the right wing correspond to the traces of solderings visible on the border of edges of the particular bas-reliefs or ledges. On the left wing, however, the location of solderings is not connected with the location of bas-reliefs and ledges (Fig. 3).

Technological investigations carried out in 1954 by T. Dziekonski and K. Wesolowski[3] have proved on the basis of micrographical and chemical analysis that differences exist in the structure and chemical composition of the two wings: analysis has shown that in the right wing there is, 82 per cent. Cu, 12.2 per cent Sn, 0.87 per cent. Pb, and in the left wing there is 12 per cent. Cu, 7.83 per cent. Sn, 2.51 per cent. Pb.

Fig. 1.—Front view of the door
(Photograph from the Woievodship Conserwator collection in Poznan)

Fig. 2.—Back view of door White lines denote visible soldering
(Photograph by T. Dziekonski)

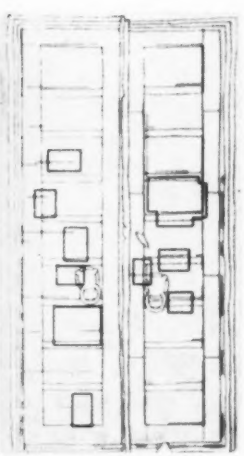


Fig. 3.—Transposition of the solderings visible on the back side of the door on to the front side

Fig. 4.—X-ray radiograph of the soldering in a bas-relief
(Taken by M. Radwan and T. Owczarski)

X-rays

At the same time, M. Radwan and T. Owczarski carried out radiographical tests by X-rays: the investigation confirmed the existence of solderings on the right wing, whereas no solderings were found on the left wing (Fig. 4) in spite of the fact that traces were visible on the back side of the door.

Research workers were then faced with the question whether each of the wings had been cast as a whole or in parts which were subsequently soldered.

Radiographs obtained in 1954 showed a number of casting defects. Thus it was decided to reproduce the technological process on the basis of the image of defects revealed by radiography; radiographs were made of the whole door and the distribution of defects in the whole casting was considered. Discontinuities in the distribution of defects would prove that the castings had been performed in parts, and their localization would show the construction of the mould.

Radiography

To obtain the radiographs the source Cs137 was used with an activity of 1.5 curie and ø 5 × 5 mm in size. In selecting the source, our own experiments on radiographic sensibility were taken into consideration. Our tests on radiographic sensibility in steel casts have shown that the highest radiographic sensibility is obtained by means of the radiation source Cs137, the thickness of cast steel being 40-70 mm[4] This thickness of cast steel corresponds more or less with the thickness of bronze (25 to 50 mm) in the door. Moreover by applying gamma radiation it was possible to perform radiographs of the cast of different thicknesses and ignoring the filler.

The radiographs were made on Polish films " Rentgen Supper CUK 44 " of a high sensitivity by using fluorescent covers Heyden M 200. Emphasis was placed on shortening exposure time; this reduced radiographic sensitivity but the defects of interest to us were still revealed.

The films were placed on the reverse side of the door the distance between the film and the source of ø 5 mm amounted to 700 mm.

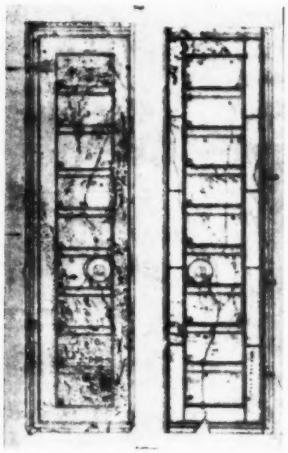


Fig. 5.—Distribution of flaws in the cast of the door as shown on γ-ray radiographs

Fig. 6.—γ-ray radiograph of a bas-relief

Fig. 7.—γ-ray radiograph of a bas-relief

Results

Radiographs, 104 in all, were made as described above, of almost the whole surface of both wings of the door, except around the hinges. The defects revealed by these radiographs can be classified as follows:

(i) Defects originating during the casting;

(ii) Cracks occurring later, as a result of the door falling or due to fatigue of the material;

(iii) Defects which were produced during later repairs of the door;

(iv) Results of corrosion.

The distribution of defects in particular wings is shown in Fig. 5. The radiographs also show the various solderings. Examples of the actual radiographs performed by means of the source Cs137 are shown in Figs. 6 and 7.

Different technology

The results of radiological investigations presented suggested a different technology in the casting of the left and right wing.

It can be assumed that the left wing has been cast as a whole, whereas the right wing has been cast in parts. In the left wing there are no solderings, but a continuous distribution of defects. On the other hand the right wing of the door was cast in parts which were then soldered together, as shown by the thick line in Fig. 5. The visible solderings and irregular defects provide evidence of this.

The radiographical investigations by means of the source Cs137 made it possible to establish the process of the door and provided the answer that the left wing of the door in the Gniezno Cathedral was cast as a whole while the right wing of the door was cast in parts.

References

[1]THIETMARI, " Merseburgensis Episcopi." *Chronicon Ed. Instytut Zachondi Poznan*, 1953, Liber N.45, p.206.

[2]MORELOWSKI. M., collective investigation: " Drzwi Gnieznienskie." *Ossolineum*, Wroclaw 1956, v.1, p.44-100.

[3]DZIEKONSKI, T., and WESOLOWSKI, K., collective investigation: " Drzwi Gniezнienskie." *Ossolineum*, Wroclaw 1956, v.1, p. 124-187

[4]RADWAN, M., GODLEWSKI, Z., and ZARZECKA, E., " Wlasnosci zrodel promieniowania irydu—192 i cezu—134 w zastosowaniu do defektoskopii," *Transaction IPPT*. PAN, Warszawa, 1958/59.

Classroom and Laboratory

Arising out of a proposal by Dr. F. R. Paulsen, at a Council Meeting of the Institution of Nuclear Engineers, several hundred teachers of nuclear science were asked to report on simple apparatus and methods used or those which might be useful for practical demonstrations in instructional courses. The response was enthusiastic. From all parts of the world, from teachers in Universities, High Schools and Colleges, from research workers, manufacturers and public relations experts, have come many ideas. As a service to teachers, and also to other workers in nuclear fields, we are now publishing the many suggestions put forward. Each suggestion carries the identity of the person who put it forward, and also a reference number. The latter will facilitate enquiries sent in by readers requiring further information. Readers are invited to submit suggestions for inclusion in this feature

No. 16 Scattering of beta particles

D. J. Carswell, Australia

A beta-source is placed near the end of a GM counter so that the beta particles will be travelling at 90° to the axis of the tube. A florin or piece of lead is used to reflect the particles into the GM tube with about 100 per cent. increase in count rate. A source placed on a thin strip and held across the window of the counter with the activity facing away from the counter will produce only a small count. A florin held in front of the source will now reflect the beta particles through 180° into the GM tube and increase the count.

No. 17 A very simple cloud chamber

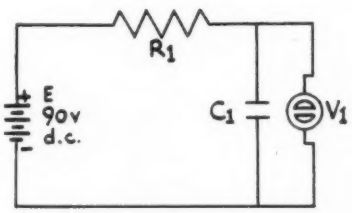
George Scherer, U.S.A.

A small piece of pitchblende is glued inside a 500 ml conical flask. The flask is then filled almost to the top with water containing a blue dyestuff. A rubber ball is attached to the neck of the flask, which is then inverted. Supersaturation is obtained by alternately squeezing and releasing the bulb, and cloud tracks appear.

No. 18 Relaxation oscillator

University Relations Division, Oak Ridge Institute of Nuclear Studies.

Electronic and electrical equipment plays such an important role in nuclear science that it is not surprising that experiments in those fields should be incorporated into nuclear science teaching. In this experiment which demonstrates the relaxation oscillator, dry cells supplying current at 90v are placed in series with a resistor and a capacitor. In parallel with the latter is a bayonet-base neon lamp. The capacitor becomes charged to a voltage given by $V=Q/C$, where Q is the capacitance. When the voltage across the capacitor reaches the firing voltage of the neon lamp, the latter will conduct, light up, and discharge the capacitor. The voltage builds up again and the firing is repeated at intervals equal to $T=RC$. An interval of 1 sec is obtained, for example, if the capacitance is 1 microfarad and the resistance 1 megohm, or if the capacitance is 1 farad and the resistance 1 ohm. Various combinations of R and C will change the time constant, so that if $R=2$ and $C=4$, $T=8$ sec. If screw terminals are used across the capacitor and resistor, the values of R and C can be varied at will.



Circuit for relaxation oscillator

No. 19 The photoelectric effect

University Relations Division, Oak Ridge Institute of Nuclear Studies.

A zinc plate, 2 in. × 2 in., is cleaned with sandpaper and mounted on top of a gold-leaf electroscope. Catskin, with ebonite or alkathene rod, or silk with glass rod, will be required for the charging. The electroscope is first charged negatively, and the zinc plate subjected to ultra-violet rays. The electroscope is slowly discharged as the zinc emits electrons. With a glass plate between electroscope and lamp, discharge ceases, as the U.V. rays are absorbed by the glass. If the electroscope is positively charged, the electrons are repelled and discharge does not occur.

No. 20 Open-air alpha counter

Harold M. Waage, U.S.A.

This alpha-particle counter, demonstrated by Mr. Waage at the January, 1959, Apparatus Competition of the American Association of Physics Teachers, won third prize. By virtue of simple construction and the audible and visual manifestation of the alpha particles, this equipment is of value in the demonstration theatre and for class use. The counter consists of a 10 kV r.f. voltage supply, a coaxial cable, a fine wire grid and backplate housed in a lucite frame, and optical bench parts are used for mounting the lucite frame and the holder carrying the alpha source. The frame is packed with a small piece of masonite which protects the wire grid. A weak alpha source is held on a small piece of wire in a small glass rod passing through a cork in the enclosed bottle. A clip clamp, on a $\frac{3}{8}$ in. rod, is mounted on one of the riders and serves to hold the alpha source horizontally towards the wire grid. The knob on the r.f. supply is advanced slowly until the meter shows about 4,500v. Beyond this voltage sparking occurs spontaneously. The operating point is just below this figure. The source is kept at a distance well within the range for the alpha particles in air, which is of the order of 3 or 4 cm.

No. 21 Mean life time demonstration

Dr. Robert Wichard Pohl, Germany.

Although the concept of mean life time has most usually been shown by the use of radioactive materials, the use of Geiger counters and electronic equipment, in a simple experiment will show the basic features.

A shallow watch-glass contains a small amount of glycerine dissolved in alcohol. A thin stream of mercury is poured into this liquid, to form a large number of minute drops, each about 1 mm diameter, the total surface area being great. Gradually the droplets will coalesce, so that the life time of the drops may be determined. Only one large drop will be left after about 1 min. The apparatus can be placed in the focal plane of a horizontal platform projector with a mirror and the image of the apparatus is cast on a large screen. Thus, the audience can watch the conversion of the many drops into one large one. The drops are " physical individuals," and one cannot predict which drop will vanish next. There is a law governing the group, since the number of droplets is reduced according to an exponential law, with a certain " mean life time." A similar law governs radioactive disintegration. This experiment is a good example of a statistical process. For a sufficient number of drops, one can determine the mean life time, say $t = 10$ sec, so that within every 10 sec the total number of droplets is reduced to a fraction of $1/e$, *i.e.*, 37 per cent. Thus, the number of droplets is 37 per cent. of the original after 10 sec, $1/e^2$ or 14 per cent. after 20 sec, $1/e^3$ or 5 per cent., and so on. If photographs can be made at intervals, the effect is even more convincing.

No. 22 A model of standing waves

Darrel Tomer and Francis L. Friedman, U.S.A.

Standing waves will be mentioned in atomic physics in connection with the electronic orbits in atoms. A model can easily be made as follows. A wooden or stout cardboard ring, say 2 in. thickness and about 30-36 in. across, has glued around it about 36 drinking straws, each having its midpoint attached to the circle, and the straws being all directed towards the centre of the circle. If a groove is cut in the edge of the wooden circle, or if the cardboard circle is mounted on spokes, it is possible to cause the rotation of the circle, by means of a thread or cord, on the principle of belt-and-pulley drive, and the straws amply demonstrate the features of the standing waves.

No. 23 Electric Field Patterns

Gilbert C. Finlay, U.S.A.

The use of iron filings for showing up lines of force in magnetic fields is very well known. It is not so generally known that electric fields may be just as simply demonstrated. Grass seed is sprinkled lightly over the surface of an insulating liquid in a Petri dish. If charged conductors are brought to the surface of the liquid, the seeds will orientate themselves in much the same way as the iron filings in magnetic experiments, and interactions of fields from various conductors may be studied in this way.

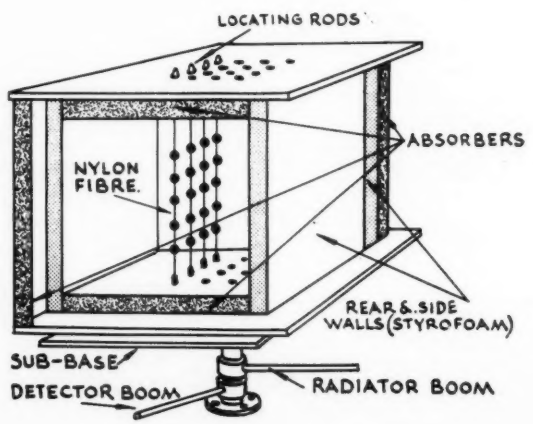
No. 24 Bragg diffraction apparatus

Robert G. Marcley, U.S.A.

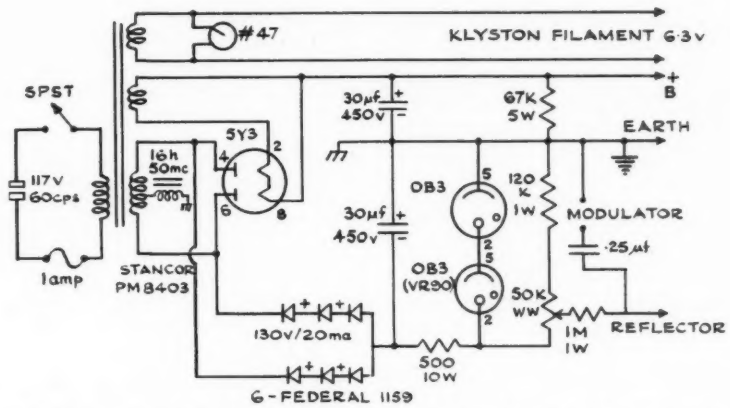
The Bragg diffraction law should be the subject of experiments by students taking advanced physics or atomic physics courses, but the use of the usual X-rays can be a real radiation hazard. The apparatus described here overcomes this difficulty. Developed under the direction of Professor Harry F. Meiners, it was designed for the Undergraduate Physics Laboratories of the Rensselaar Polytechnic Institute under a grant from the General Electric Co. Using 3 cm microwaves, it produces data differing from the theoretical by only 10 per cent. or less.

The base and top of the box are of 24 in. × 24 in. × ½ in. pressed board or phenolic or acrylic plastic; the two side walls are of 16 in. × 20 in. × 2 in. Styrofoam (Dow Chemical Co.), which is transparent to microwaves, secured to the base and top with ¼ in. diameter wooden pins and casein glue. Front and rear walls are of 20 in. × 20 in. × 2 in. Styrofoam also. To prevent the introduction of spurious reflections, microwave absorbers are provided. Top and bottom absorbers consist of mats of loosely spun animal hair impregnated with rubber containing carbon black to conduct r.f. waves. These mats are 16 in. × 16 in. × 2 in. and of type 12CM (Goodrich Co.), permanently installed at top and bottom inside the outer sheeting, and fixed by Pliobond cement and light brads. Similar absorbers inside the four walls are 24 in. × 20 in. × 2 in. in dimensions, secured by light brads, these absorbent sections offering no interference with the incident and diffracted beams. The absorbent also controls room reflections and isolates adjacent laboratory stations.

The power source is a Western Electric 723A/B(2K25) reflex klystron mounted in a standard horn radiator fixed to a boom so that the angular position of the radiator with respect to the lattice may be adjusted. The



Bragg diffraction apparatus



Simple power supply for WE723A/B(2K25) reflex klystron for use with Bragg diffraction apparatus

klystron is modulated by a 1,000 cps square wave supplied by an inexpensive audio signal generator. For a lattice spacing of 4.25 cm, the optimum wavelength is 3.4 cm.

The cubic lattice with a_0=4.25 cm is made from $\frac{3}{8}$ in. drilled aluminium spheres cemented to nylon fibres in strings of four with a spacing of 4.25 cm between spheres. Sixteen of these strings are adjusted independently in a vertical direction for optimum alignment. The diffracted power is detected by means of a standard 3 cm horn, waveguide type of crystal mount, IN23A silicon diode, and a standing-wave indicator such as the Hewlett-Packard 415B. This indicator produces an amplified audio-frequency signal which will activate a CRO or, with suitable intermediate amplifier and synchronized sweep circuit, an X-Y plotter. A power amplifier and loudspeaker may be used for demonstrations to classes.

The original apparatus has a boom system giving adjustment of angular positions of power source and detector independently with respect to each other and the lattice. More complicated lattices may be built up.

No. 25 Simple Exponential decay Analogy

R. A. Faires, U.K.

This demonstration is almost absurd in its simplicity, yet warrants mention because of the effectiveness of its teaching power. A sheet of newspaper is torn into two halves, then one of these halves into two halves again, and so on. The areas of successive pieces lie in exponential relationship.

No. 26 Indestructibility of radiation

R. A. Faires, U.K.

The indestructibility of radiation may be demonstrated if a small piece of radioactive gold foil be welded on to a platinum wire. The foil may be heated to redness in the bunsen flame without any reduction in the radioactivity.

No. 27 Atomic kit for youngsters

Nuclear Chicago Corporation, U.S.A.

Nuclear Chicago's Radionuclide Set RNS-100 may be looked upon as the atomic era's chemistry set. It provides both beta and gamma emitters of various half-lives and energies. The eight reagent bottles, each containing 5 mls, provide C14, P32, I131, S35, Zn65, Na22, Co60 and Fe55/59. Although sufficient activity is supplied in each reagent for many experiments, no AEC licence is required for purchase or use of the set, which includes also a micropipette, a pipette syringe, and 100 stainless steel sample planchets for preparing the samples. The price is $35.40, which is quite reasonable. This set enables chemistry and biology teachers to introduce tracer techniques into their curricula.

No. 28 A package isotope kit

Nuclear Chicago Corporation, U.S.A.

Another attractive set marketed by this firm, which should appeal to colleges, is the Nuclear Chicago Model 1613A Classmaster, which costs $194.50. The Classmaster is a nuclear demonstration and experiment system for the teaching of fundamentals of radioactivity, and it is rugged, dependable, and versatile, an educational tool suitable for all-the-year-round student use. Being a single compact " package " system, it can be easily moved from the classroom to the laboratory. Its electronic count rate indicator has an internal, variable high-voltage supply for the GM tube, the meter reading on two ranges, 0-1,500 and 0-15,000 cpm and the radiation intensity is indicated also by a variable tone speaker and by a blinker light. The indicator operates from a 100v source. A set of lead, aluminium and cardboard cylinders is used to illustrate scattering of radiations, while absorption in media can be studied by means of a set of absorber sheets of these same materials. There is a sensitive thin-wall GM counter on a probe, allowing both gamma and beta detection, a 54 in. cable being provided. The calibrated experiment board has a probe clamp, source-positioning groove and absorber slots to simplify absorber, geometry and coincidence loss studies. Two radiation sources are mounted in unbreakable plastic cylinders. The experimental manual contains lecture material, laboratory experiments and questions and answers, and suggestions for further investigations.

No. 29 Useful technical bulletins

Nuclear Chicago Corporation, U.S.A.

Nuclear Chicago Corporation has developed and distributed a series of technical bulletins which can be heartily recommended as eminently suitable for use by teachers of radiochemistry and nuclear physics. In this series, No. 1 deals with the use of radioisotopic yield determination in quantitative, described in a crystal-clear manner, and illustrated with examples. Radioisotopic analysis is the subject of Bulletins 2 and 3, while No. 4 is concerned with chromatography, No. 5 covers the evaluation of analytical methods by isotopes, and No. 7 deals with the preparation of counting samples on planchets.

Institution News

100 guineas award

Italian paper

Foreign relations

Cleaning—preservation—packing symposium

THE award of 100 guineas for an Institution Paper has been made. It is shared by two papers which the adjudicators consider to be of equal merit. They are "The siting of nuclear power reactors in the U.K.," by A. Quinton, and "Electric power from nuclear heat—direct," by J. W. Gardner. The award will be divided between the two authors. Mr. Quinton's paper will be presented to a meeting of the Institution at Caxton Hall on May 2nd and Mr. Gardner's on May 9th, both at 6.30 p.m. Both papers will be published in the May issue of the Journal and written discussion is invited. It has been decided to make the award annually.

Italian paper

It was announced at the February Council Meeting that an offer had been received from Professor Dr. Otto F. Joklik, Director of the Italian Nuclear Research Centre, Rome, to read a paper on a special blood treatment to combat radiation injury to man. The lecture will take place at the Junior Institution of Engineers on May 18th at 6.30 p.m. Professor Joklik will also show a film, "From Cobalt to the Cobaltron."

Belgian Royal Society

The Institution has accepted an invitation to establish relations with the Belgian Royal Society of Engineers. At the February Council Meeting a letter from the Society was read and it was decided to accept applications from members of the nuclear section of the Belgian Society for membership of the Institution without investigation. It was proposed that similar facilities might be accorded to members of the Institution who wished to join the Belgian Society.

The Conference Committee reported to the Council on progress with the symposium on Cleaning, Preservation and Packing of nuclear materials and equipment. There is to be a registration fee of 10*s*. for the symposium which will take place on October 5th and 6th, 1961 at Caxton Hall, London. A total of six papers will be presented with the following titles; 1 Why clean equipment?; 2 Fundamentals of cleaning and preservation; 3 Clean rooms and other facilities; 4 Site clean conditions; 5 Problems in packing, preservation and transportation; 6 Tests and standards of cleanliness. Each paper will be followed by a discussion.

The main purpose of the conference is to bridge the gap between engineers working in the nuclear field on the one hand and designers, physicists, etc. on the other. This is a field of activity where both have problems in common, the one desiring to maintain physical and chemical standards and the other seeking practical means of achieving these standards in the everyday engineering world. Few publications exist in this field and there is little opportunity for pooling knowledge. In fact few real standards have been established and it is the object of the symposium to emphasize the importance of adequate standards.

Preliminary steps have been taken to form a Scottish branch of the Institution. If the response is sufficiently enthusiastic an inaugural meeting and lectures will be arranged for next winter. No doubt a Scottish branch operating on a local basis and holding lectures and discussion groups in Scotland will be of considerable benefit to our members there. All those interested in the formation of this branch should contact Mr. J. H. Woodward, 85, Rannoch Drive, Bearsden, Dunbartonshire.

NEW MEMBERS

D. A. Alderton, A
Tilehurst, Reading, Berks.

R. J. McBain Allan, JM
Watford, Herts.

D. N. Astbury, SM
St. Helens. Lancs.

J. C. Bell, M
N.S.W., Australia.

J. J. Brzozowski, JM
London.

R. W. Burridge, A
Bracknell, Berks.

G. W. Candy, A
Stechford, Birmingham.

D. D. Carruthers, A
Newcastle.

D. J. Chapman, A
Waltham Cross, Herts.

R. Cotterill, M
Carlisle, Cumberland.

D. A. Dunkason, A
Bracknell, Berks.

R. R. Echandi, M
Costa Rica,
Central America.

J. D. Egginton, A
Mickleover, Derby.

W. T. Fisher, M
Warrington, Lancs.

I. C. Forbes, M
Dorchester, Dorset.

R. E. Gill, A
Egremont, Cumberland.

N. J. Gordon, A
Gosport, Hants.

A. D. Holland, JM
Birmingham.

C. H. Hall, SM
London.

Lt. C. A. Hely-Hutchinson, A
Barrow-in-Furness.

R. A. Hockin, JM
Castle Bromwich.

B. Hogan, A
Lower Stanwick, Hants.

J. Leitner, JM
Alaska.

F. G. J. Lorenz, AM
Southall, Middx.

D. C. Metcalf, JM
Birmingham.

J. Mullins, M
Knutsford, Cheshire.

B. T. Paling, JM
Castle Bromwich.

P. I. Parker, M
London.

Lt. Col. S. W. Peet, A
Salisbury.

D. A. Phillips, A
Aldridge.

E. Poole, M
Dartford, Kent.

T. J. Price, A
Essex.

J. A. Reynolds, M
Cumberland.

R. H. Rossiter, JM
Castle Bromwich

J. B. Savin, M
Reading.

M. K. Sivers, M
Bexley, Kent.

G. W. Sutton, AM
Wednesbury.

S. Thornburn, M
Glasgow.

B. A. Waller, A
Basingstoke.

F. D. Walls, AM
Cumberland.

G. Watson, M
Maidenhead.

B. J. Wilson, JM
Tamworth.

M. C. Whitaker, A
Annan, Dumfriesshire.

Book Reviews

Resonance Absorption in Nuclear Reactors, by Lawrence Dresner. Published by Pergamon Press (Oxford, London, New York, Paris) in the International Series of Monographs on Nuclear Energy (General Editors: R. A. Charpie and J. V. Dunworth) as Vol. 4 of Division X (Reactor Design Physics). Size 5¾ in. × 8¾ in. × 131 pp. Price £2.

This very timely addition to the International Series of Monographs on Nuclear Energy has been eagerly awaited by reactor physicists throughout the world ever since the title was announced by the publishers. The author has been well in the forefront of research work on the theory of resonance absorption ever since the first Geneva Conference in 1955, having made valuable contributions to many different aspects of the subject. Some of his more recent work is, in fact, published for the first time in this monograph. The book opens with a very interesting and up-to-date historical review, giving an extremely comprehensive list of references to papers published on resonance capture up to the end of 1959. Next comes a consideration of slowing down and absorption in both narrow and wide resonances in homogeneous media. The Wigner approximation and the Goertzel-Greuling approximation are derived both by Hurwitz's WKB method and by Weinberg and Wigner's Placzek function method, the order of accuracy and validity of each approximation being thoroughly investigated. The natural line shapes are treated first and then Doppler broadening is taken into account, with and without interference effects. Succeeding chapters deal with resonance absorption in lattices and the reduction of both Narrow Resonance and Infinite Mass heterogeneous resonance integrals to equivalence with the corresponding homogeneous cases by means of Wigner's rational approximation. The error introduced by the use of this approximation is investigated in considerable detail. Special topics treated in the penultimate chapter include close-packed lattices, clusters and unresolved resonances, while the final chapter consists of an exhaustive comparison of results obtained by theoretical and experimental means. In general the material is well presented and it would be difficult to imagine a more comprehensive treatment of the subject in such a compact form. The use of asterisks, denoting sections which may be omitted on a first reading, enables the reader to obtain a good grasp of the subject matter without becoming bogged down in a morass of detail. However, in a few places the meaning of sentences could be clarified by slight rearrangement, *e.g.*, the second sentence of paragraph 9-2 and the fourth sentence of Chapter 3. Further, the reader may find slight difficulty in becoming accustomed to the unusual way of numbering equations, figures, etc., and will probably wish for a list giving the meanings of all the symbols used. There are a few minor errors, most of which will cause very little trouble to the reader, such as a misprint in " neutron " on p. 27, " clusters " instead of " rods " in the title of Table 17-8, " Case, Placzek and de Hoffmann " consistently instead of " Case, de Hoffmann and Placzek," and " 142 " instead of " 155 " in the reference to the Geneva paper by Adler *et al.* The sentence containing equation (23-3) is very loosely expressed, referring to " the area under " a function of two variables, and its intended meaning is made even more obscure by the printing of " x " instead of " 0 " in the first line. In the definition of resonance cross sections on p. 27, there is some confusion between the energy dependent γ_n and the value of γ_n at exact resonance energy E_0. Thus σ_0 appears to be defined as an energy variable in equation (3a-3), although it is defined on p. 29 in the usual way as the total resonance cross section at energy E_0. This confusion is partly responsible for the rather strange statement on p. 32: "...it is a good approximation to ignore the *energy* dependence of σ_0, γ and E over the range of integration..." While the author is careful in general to specify the conditions of validity of his statements and equations, he neglects to state that in paragraph 2-2 the target nuclei are assumed to be at rest and he also omits to mention this restriction in reference to the cross sections defined on p. 27, except in retrospect on p. 33. In spite of the few shortcomings mentioned above, the book as a whole is worthy of high praise and stands alone as a comprehensive exposition of the theory of resonance absorption in nuclear reactors. It will be found extremely valuable by all students of the subject and by all who are interested in the theory of reactor design.

M. H. McKAY

Materials for Nuclear Engineers. Edited by A. B. McIntosh and T. J. Heal. Published by Temple Press, Ltd., London. 373 pp. Price 75*s*.

It is perhaps now a platitude to say that with the coming of nuclear energy the engineer had to accustom himself to quite new concepts. Materials such as beryllium, zirconium, pure graphite, and so on, long regarded as chemical curiosities, suddenly became work for the drill, the lathe, and the production line. Impurities which could previously be disregarded suddenly achieved a new importance. Mechanical properties had to fit into quite new and more rigid specifications, and nuclear properties came to be something which had to be taken into account. Plant which would normally be subject to maintenance on a weekly, monthly or annual basis had to be designed for very long and continuous operations without the benefit of electrician or mechanic, and remote operations called for new types of control systems, new considerations of planning and design. The new generation of engineers, the engineers of this nuclear era, have coped well with their novel assignments, largely because of their adaptability. But the future generations will have to accept these new conditions and new materials as part and parcel of their everyday curricula in college and of their everyday work later on. They will grow up with them, in fact. This can become possible only with sound training and sound training, in its turn, will depend upon the availability of reliable textbooks. Among the latter, I am convinced, will appear as one of the standard works, this volume by McIntosh and Heal. Dr. McIntosh, as head of the Culcheth Laboratories of the UKAEA, has had an almost unrivalled experience of the newer materials which have found their way into engineering today. This experience has enabled him, ably assisted by Mr. Heal, to tackle the real problem of editing nine sections in this invaluable book on materials. Dr. McIntosh has written the first section, on the use of materials information, while Mr. Heal has contributed material on magnesium. There are other sections, too, on uranium, plutonium, thorium, graphite, zirconium, beryllium, and ceramic fuels. Perhaps the two most striking omissions, though perhaps these were purposely avoided, are heavy water and sodium metal, both of which are now being handled in vast amounts by nuclear engineers. Each section has been presented with an authenticity and clarity of style which leave little to be desired. The text is amplified by means of a large number of good photographs, graphs and tables of data, and each section has also an adequate bibliography. As far as possible, each section has been framed on certain specific lines, so that there is a commendable uniformity about the volume. If one may take the section on uranium as an example, we find that this metal is dealt with under the headings of occurrence, extraction, preparation, physical properties, mechanical properties, creep properties, compatibility, fabrication, effect of reactor conditions, and a general selection of concluding remarks, with an appendix on data. I am convinced that it would have been virtually impossible to compress such invaluable information into smaller compass without making the book unreadable. But the fact remains that the book *is* readable, and this is one of its excellent features. It will certainly appeal to the student. On the other hand, it is also a work of reference, and as such will also find a place on the bookshelf of the professional engineer, who may have need for reliable data for the solution of some numerical problem or design assignment. A survey of the bibliographies is sufficient to show that an effort has been made to draw references from as wide a field as possible, a commendable feature which is not so noticeable in many of the books I have reviewed in the past. It is interesting to see that in the paragraphs on energy storage in graphite, no reference has been made to the name " Wigner," and (less remarkable perhaps) no reference to the now-famous Windscale incident.

F.R.P.

Westminster talks about...

by Peter Lewis—Our Parliamentary Correspondent

BRITAIN'S lead in nuclear power stations has given her a new and increasing source of revenue from the export of isotopes, and this month, Members were concerned mainly with questions on isotope production and the use of nuclear power for marine propulsion. In the Lords, the Electricity (Amendment) Bill was debated and **Lord Shackleton** moved an Amendment. He was anxious that the Bill, which gives powers to the CEGB to manufacture isotopes, be extended to allow the Board to process and market them. He pointed out that when the irradiated material emerges from the pile it is then properly processed at the Radiochemical Centre of the AEA. If, however, there was nothing to prevent private firms carrying out the necessary operations involved in the processing of isotopes, why should that advantage be denied to the CEGB. While the likelihood of private companies processing isotopes seemed remote, the reason for his plea was that not only would the CEGB have considerable experience in this field but the AEA's resources were fully occupied.

Position of CEGB

Replying to Lord Shackleton, **Lord Mills,** the Paymaster General, acknowledged Lord Shackleton's forward looking aspect in the matter, and emphasized that the AEA had all the resources and scientific skill to deal with the problem, and there was some anxiety over the prospect of empowering the CEGB to dissipate its energies in looking for staff and to do the same thing that the AEA were well qualified to do. Lord Mills also considered that private enterprise possessed many skills and technical staffs which might well contribute to the national benefit in this particular field. It had been Lord Shackleton's argument that as the CEGB could not help manufacturing isotopes and would go on doing it whether anyone liked it or not, it seemed absurd not to encourage the Board to do anything other than generate electricity. **Viscount Alexander of Hillsborough** also supported this concept, but Lord Mills countered this by saying that the capacity of the Generating Board to irradiate materials would be used to the full and although the AEA was approaching the limit of what it could do, it possessed the means of processing and had added to its capacity at Amersham. The Authority had the staffs and marketing techniques and had studied and developed the whole process. He suggested that if still further capacity was needed it would be reasonable to look first and see whether it would not be wise and proper and economic to develop Amersham rather than start a new body and have to provide new staffs. The House divided, and the Amendment was defeated.

Nuclear Ships

In the Commons, **Mr. Hector Hughes** (L., Aberdeen N.) asked the Minister of Transport if he was yet in a position to make a statement on the progress that had been made towards the construction of British-built nuclear merchant ships and fishing trawlers and when did he expect the first of these to be seagoing. **Mr. Patrick Wall** (C., Haltemprice) had also put down a question asking the Minister when he would announce the award of a tender for the construction of the first British nuclear-powered merchant ship. Replying, **Mr. Ernest Marples** said that the examination of the tenders for a nuclear reactor and propelling machinery suitable for installation in a tanker of 65,000 tons deadweight was proceeding as quickly as possible. He was not able to say however, when a decision would be made, and he added that nuclear propulsion could not reasonably be considered for any but large ships at the present stage. In answer to a further question from Mr. Hughes, Mr. Marples said it would be silly to suggest that smaller ships could not eventually use nuclear propulsion, but the first thing was to take a ship of optimum size, endeavour to make it an economic proposition and carry on from there. Mr. Wall reminded the Minister that it was two years since the Galbraith Committee was appointed and six months since he had received tenders, and didn't the Minister agree that until Britain had practical experience with a ship at sea she was unlikely to lead in this new development. The Minister did not agree that an undue length of time had elapsed, the five tenders had been received on July 29th last year and the technical committee had considered them. It was a very complex subject and no mistakes must be made. The Minister ended by telling the House that the technical committee had practically concluded its assessment and would be meeting shortly to draw up its report.

Consortium

In a written reply later in the month to Mr. Hector Hughes, regarding the officially-sponsored consortium of shipowners which was to own and operate the first British-built nuclear ship, Mr. Marples said that the consortium had not yet been formed.

NUCLEAR NOTES

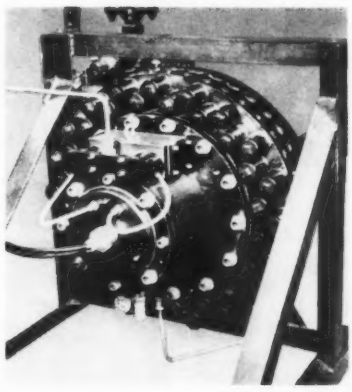
German ship

THE contract has now been signed in Hamburg for Euratom's participation in a nuclear marine propulsion project currently being carried out by the Hamburg Gesellschaft fuer Kernenergieverwertung im Schiffbau und Schiffahrt MBH (Company for the Application of Nuclear Energy in Shipbuilding and Navigation). The contract was signed by the European Atomic Energy Community (Euratom), the Gesellschaft fuer Kernenergieverwertung im Schiffbau und Schiffahrt MBH, and also by the firm of Interatom (Internationale Atomreaktorbau GmbH, Bernsberg/Cologne). A contract providing for joint development of a nuclear marine propulsion unit of the organic moderated and cooled reactor type (OMR) was concluded early in 1959 between the firm of Interatom and the Gesellschaft fuer Kernenergieverwertung, which had been making a two-year preliminary study of the problem. This one-year contract was later extended until 1961, by which date it was planned that the design work and special tests scheduled to be carried out would produce working designs. Euratom participation will cover the whole design phase for the organic moderated reactor up to and including the completion of working designs, which are expected to be ready by the end of 1961. Under the contract, Euratom will contribute a sum of up to 4.48m. DM. to the project. Once designs for the nuclear marine propulsion unit have been completed, tested and approved, it is intended to go ahead with construction and trials of the propulsion unit with an actual vessel. Under the contract, Euratom will be able, if it so wishes, to be associated with this work. Euratom aims at co-ordinating the various efforts being made in the field of nuclear marine propulsion and encouraging the exchange of information and experience. At present it is negotiating three further contracts, one of which is due to be concluded very shortly. These are: (1) a contract with the French Atomic Energy Commission for the construction of a gas-cooled high power ship's reactor. This type of reactor also shows promise for use in nuclear power plants; (2) a contract with Fiat and Ansaldo of Italy for a light water-cooled ship's reactor operating on enriched uranium; (3) a contract with various bodies in the Netherlands for the construction of a pressurized water ship's reactor. In these cases, the parties to the German agreement will have an opportunity of seconding staff to exchange ideas and information, just as experts from various groups in other Community countries will be able to benefit by the experience gained with the German project. No decision on the actual construction of the vessel will be made before the beginning of 1962 at the earliest. It is estimated that the ship will take 2 to 2½ years to build and that, given present costs and wages, the cost will be in the region of 35m. DM.

Trawsfynydd valve

THE outstanding features of a 40-way selector valve developed by Plessey Nucleonics, Ltd., for the burst fuel element detection system at Trawsfynydd nuclear power station are its reliability and full efficiency under the special operating conditions which require it to work unattended for periods of two years. This means that since the valve has a cycling time of 30 sec, it will cycle more than 2m. times in that period. These features have been achieved by advanced metallurgical and mechanical development, with the entire driving mechanism grouped in a serviceable sub-assembly which incorporates a self-sealing device for rapid removal, on load, without additional shut-off. This sub-assembly can be removed and replaced without difficulty in less than 20 min. In order to ensure positive and accurate location at each index, a unique ratchet indexing mechanism has been built into the valve. As a result of the valve's contained pneumatic operation, which makes an external driving shaft unnecessary, there is no need for rotating shaft seals and the static seals used ensure that the leakage to atmosphere is zero. Equipment for the detection of serious element failures during reactor shut-down is also being developed by PNL for Trawsfynydd. This makes use of the characteristic alpha emission of uranium.

The 40-way selector valve developed by Plessey Nucleonics, Ltd., for the burst slug detection system at Trawsfynydd nuclear power station



UKAEA valve

TWO UKAEA engineers have designed a versatile valve for fluid flow control. This valve can be adjusted to provide a good range of flow characteristics and is the subject of a patent application by the Authority. The heart of the device is its specially-shaped seating and closure sections which can readily be used with some existing commercial valve bodies. Both of these carry tongues which are interleaved, but can slide between each other in such a way that the liquid is made to pass through ports defined by them. Flow characteristic adjustment is by a movable shutter over the spaces between the tongues on the closure section. The shutter normally rotates but can be made to slide axially. In this case the choice is available of keeping the ports closed during the earlier part of the travel of the closure section, or of having a constant flow rate during the latter part of the travel. Either type of shutter can be profiled to give a wide variation in flow rate characteristics. A rectangular profile would give substantially linear characteristics, while a logarithmic profile could be arranged to give a logarithmic pattern. A sealing ring mounted on the closure section is co-ordinated with the seating section to provide sealed closure of the valve. The axially moving closure section is carried by a valve spindle, the gland being made leak-tight through the use of a flexible metal bellows sealed at one end to the valve body and at the other to a disc integral with the valve spindle. The valve can readily be adapted for automatic operation from a process controller and can be adjusted by conventional electrical or fluid operation without interfering with the automatic system controls.

Waste disposal contract

THE hundredth IAEA research contract has gone to the Institute of Nuclear Research, Prague, for a research project to ascertain the physico-chemical requirements for the disposal of low-activity liquid radioactive wastes in soil. With the growing use of radioactive materials in research and industry the safe disposal of radioactive wastes assumes an ever-increasing importance for the present and future development of nuclear energy programmes in many countries. One of the most important aspects of this problem is the safe disposal of low-activity liquid wastes. These wastes, in spite of their relatively low activity, need special methods of disposal depending on

NUCLEAR NOTES

individual situations. The aim of the research contract is to work out a method of radioactive waste disposal by injection into soil and to study the course of plugging in suitable geological formations. This method of disposal appears at present to be the only possible one for many countries with geographical and geological conditions similar to those in Czechoslovakia. The Agency's research contract programme, established in 1958 to encourage and assist research in atomic energy for peaceful uses throughout the world, includes the following subjects: (*a*) safe disposal of radioactive wastes (21 contracts in 11 countries); (*b*) health physics and radiation protection (21 contracts in 13 countries); (*c*) radiobiology (29 contracts in 20 countries); (*d*) development of safeguards procedures (8 contracts in 8 countries). In addition to this, 21 research contracts have been awarded on power reactor studies and various applications of radioisotopes and radiation in agriculture and medicine. The 100 research contracts have been awarded by IAEA to institutions and laboratories in the following countries: Italy (10); Austria (9); Japan (9); France (8); United Kingdom (8); Germany (Fed. Rep.), Norway, Poland and the United States (4 each); Belgium, Czechoslovakia and Yugoslavia (3 each); Sweden, Netherlands, Switzerland, Israel, Australia, China, United Arab Republic, Union of South Africa and India (2 each); Greece, Finland, Argentina, Philippines, Iraq, Thailand, Brazil, Denmark, Spain, Hungary, Portugal and Chile (1 each). One contract was awarded to an international organization. At present the board of governors are reviewing the practices and procedures followed in awarding research contracts.

Muon experiment

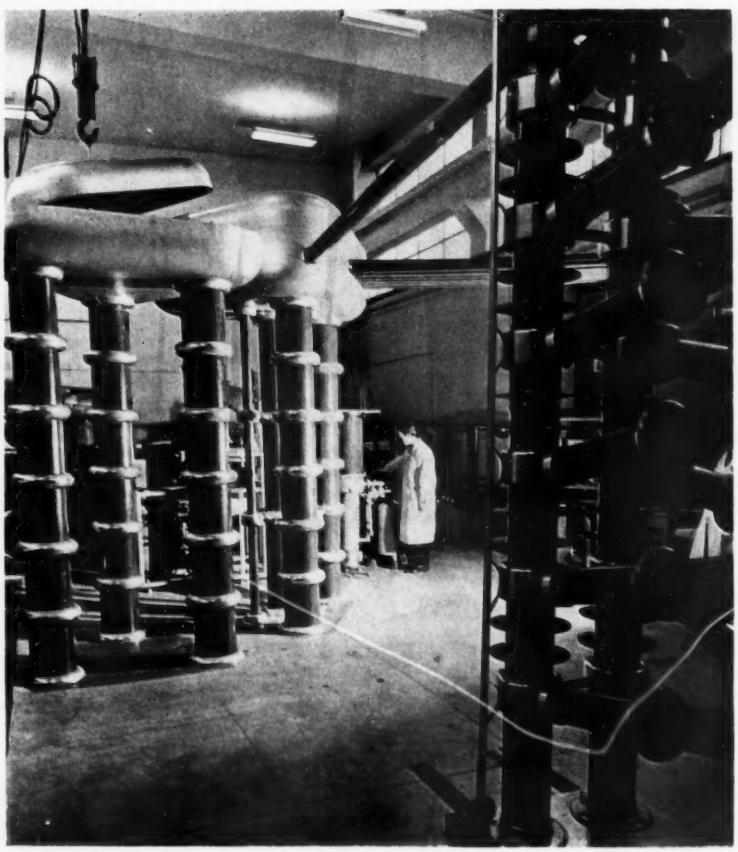
AN experiment carried out by Professor Gilberto Bernardini at CERN shows that the *muon* (or mu meson) can now more than ever be called a heavy electron. The results obtained confirm also the validity of certain laws of physics quantum electrodynamics at the very small distances involved in particle physics. Information has also been obtained about lower limits of the dimension of the muon and of a fundamental length in physics. Scientists working at Meyrin have devised the so-called " g-2 " experiment to find out to what extent the muon is identical to the electron, in spite of the difference of masses (207 to 1) between those two particles. Broadly speaking, " g-2 " consisted of a high precision measurement of one of the physical characteristics of the muon: its magnetic moment. The scientists foresaw that if the muon was a heavy electron showing no interactions different from those of the ordinary electron, then a branch of physics called quantum electrodynamics should let them calculate exactly the muon's magnetic moment. A deviation from this calculated value might entail several explanations, each of which could indicate a real difference between the muon and electron. If the experiment showed no deviation from the predicted values, then the scientists expected that new limits would have been established to the validity of quantum electrodynamics and to other fundamental assumptions in physics. The " g-2 " experiment completed recently has shown the experimental value of the magnetic moment of the muon to be in agreement with the theoretically predicted figures, within the limits of two parts in 100,000. This agreement between theory and experiment also allows several fundamental deductions, very important for deeper knowledge of the laws of nature. These are that (*a*) the laws of quantum electrodynamics are valid at very small distances and more precisely down to 0.7 fermi, that is 0.7×10^{-13} cm or still, one fourteenth of a millionth millionth of a cm; (*b*) the muon or heavy electron can be visualized as a pointlike particle or tiny sphere no bigger than 0.3 fermi in radius (0.3×10^{-13} cm, or one-thirtieth millionth millionth of a cm); (*c*) any *fundamental length* which one may think of introducing as a limit to the relativistic invariance of physics, is less than 0.2 fermi (0.2×10^{-13} cm or one-fiftieth of a millionth millionth cm).

South African uranium

A NUMBER of important aspects of the South African uranium production programme have been discussed recently by the South African Atomic Energy Board and the Combined Development Agency (the Agency consists of the United States Atomic Energy Commission and the UKAEA). Arrangements between the two organizations have been in operation since 1952 and these discussions were aimed at price stabilization, reconsideration of the quantities to be delivered and the extension of the period of operation of the arrangement so as to ensure the continuance of the South African uranium industry beyond the date of expiry of the present agreement. The new agreements will operate until the end of 1966 and provide for the delivery to the Agency of 28,350 tons of uranium oxide at prices varying as between individual producers and calculated on an

Polish Research Institute

View of the linear accelerator at the Institute of Nuclear Research at Swierk in Poland



NUCLEAR NOTES

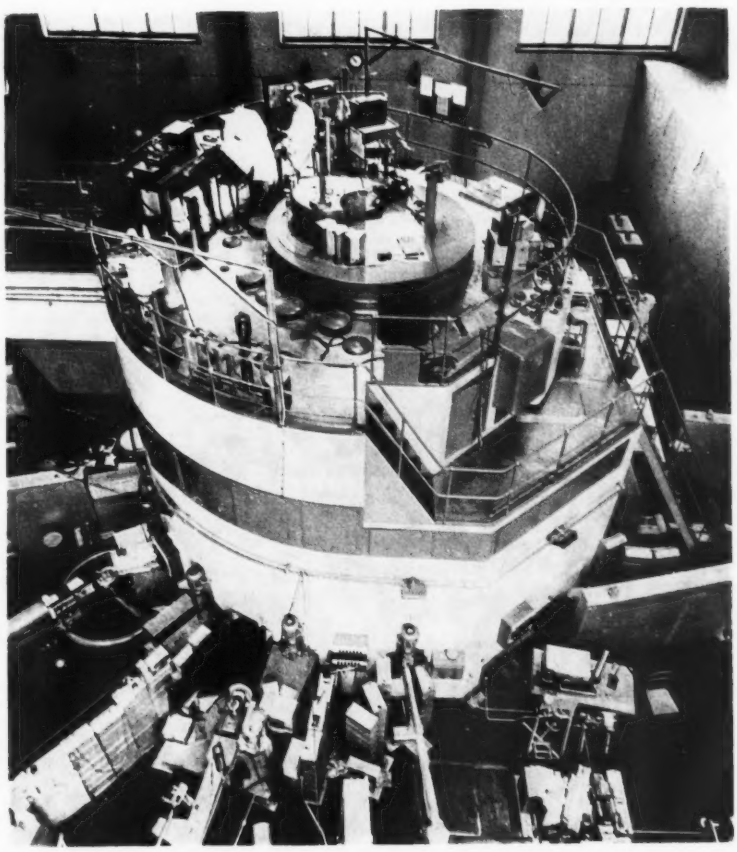
incentive cost type formula. Thus, the total amount of uranium to be acquired by the Agency is the same under the new and old agreements. However, a reduced rate of delivery to the UKAEA will result in the deferred delivery of 5,953 tons during the period January 1st, 1967 to December 31st, 1970, while the average combined rate of delivery to the Commission and the Authority during the period ending December 31st, 1966, will be reduced from 4,725 tons to 3,733 tons. Instead of the former price arrangement, agreement has been reached on a fixed price for the total tonnage to be delivered to the Agency. This will enable each producer to receive a price related to that received previously. These features of the new agreement have been made possible by the realization by all concerned of the advantages to be gained from such a rationalization of the South African uranium industry as should prove feasible through the transfer of production from high to low cost producers. The new agreements will enable such transfer of production to be effected on the authority of the Minister of Mines for South Africa after recommendations by the Atomic Energy Board, and the reduction or cessation of operations by certain production units will result. As part of the new price arrangements the agreements now concluded provide for the transfer to South African producers of ownership of Calcined Products (Pty.), Ltd., which has been responsible for the processing of the material before shipment and undertakings have been given to maintain the quality of the material at the same high standard as hitherto.

Fast burst reactor

A SMALL research reactor to provide short bursts of radiation for biomedical and health physics research will be constructed at Oak Ridge National Laboratory in the U.S.A. Designated FBR (Fast Burst Reactor), it will consist principally of a core of uranium molybdenum alloy without shielding or moderator. Radiation exposure will be very small outside the limited access area. Location will be in a hollow surrounded by hills of sufficient height to provide adequate shielding for surrounding areas. The reactor design provides for a pulse of 40 microsec consisting of fast neutrons as free as possible of thermal (slower) neutrons. In addition, the reactor can be operated under constant, steady state conditions at power levels up to 1 kW. Some experiments will be performed inside the reactor building while others requiring additional unobstructed space for certain measurements will be conducted in the open on a concrete apron. A boom derrick will be provided for outside use to allow for operations between 30-50 ft high. The research programme with the FBR will be mainly concerned with radiation dosimetry in connection with instrument development and dose determinations and radiobiology programmes involving both large and small animals. The facility will also be available for programmes involving medical uses of ionizing radiation, solid state physics, nuclear chemistry, and neutron physics research. Construction is scheduled to start about April 30th next, and is expected to be completed by April 30th, 1962.

Polish Research Institute

The water moderated "EWA" reactor at the Institute of Nuclear Research at Swierk in Poland. A second graphite-water moderated reactor of Polish construction is to be built soon with a considerably increased area available for research purposes



Columbia buys TRIGA

COLUMBIA UNIVERSITY has announced the purchase of a TRIGA research reactor. This will be the first reactor to be installed and operated in New York City. The reactor is to be used by graduate students for wide research activities and also for the production of radioisotopes for training. Professor Charles F. Bonilla is supervisor of the project. The university already has three sub-critical nuclear assemblies which are used primarily for teaching but these are not capable of initiating a chain reaction.

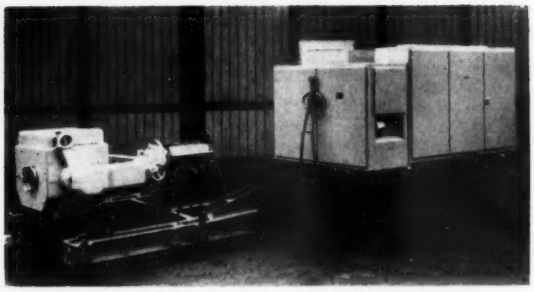
IAEA assistance

THE IAEA board of governors has been meeting recently to consider requests for technical assistance from 16 countries at a total cost of $U.S. 513,000. The board is also giving further consideration to the question of safeguards against the diversion of Agency assistance to non-peaceful uses. The board is to receive a progress report on the proposed arrangements for providing emergency assistance in case of radiation accidents. A draft international convention on civil liability for nuclear damage, comments on the draft received from member governments, and proposals for further action in this field will also be submitted.

Head Wrightson betatron

HEAD WRIGHTSON (Teesdale), Ltd., have placed an order with Pantak, Ltd., for an 18 MeV Siemens betatron. This mobile particle accelerator, the most sensitive X-ray unit currently planned for use by U.K. industry, can be used for examining steel thicknesses of up to 16 in., and reflects

NUCLEAR NOTES



Siemens 18 MeV betatron

the growing trend towards welded fabrications in plate of increasing thickness and of denser metals. This trend is particularly pronounced in the fabrication of pressure vessels for the nuclear power and refrigeration industries. The unit will operate in the heavy fabrications shop at Thornaby-on-Tees and will require less radiation safeguards than those which must be adopted for other particle accelerators and high power sources. Amongst the first applications of the betatron are expected to be those of weld examination on the 4 in. thick walled steam raising units or heat exchangers for Dungeness nuclear power station. A 4 in. thick weld can be examined in less than 2 min. The extremely fine size of the platinum X-ray source or focal spot at 0.3 mm × 0.2 mm, is of particular significance. This feature is responsible for the high definition contact radiography which will be carried out with this unit in which wire penetrameter sensitivities of 0.3 per cent. will be possible when examining 10 in. thick steel plate. It also governs the enlargement technique in which such fine flaws as that of a crack some 0.1 in. deep in a 10 in. thick plate can be observed in addition to other defects which would be beyond the range of such equipment as conventional X-ray units, isotopes and linear accelerators. The betatron radiation head, which uses an 800 lb magnet assembly to accelerate electrons almost to the speed of light in a doughnut-shaped tube before grazing the platinum target, weighs one ton and is gimbal mounted to allow any sequence of exposures to be made at any angle without the need for relocating the machine. It is provided with internal shielding and the radiation output falls away rapidly outside the useful beam, thus simplifying personnel protection problems. Practical working conditions are frequently obtained with mobile steel protecting screens, these limiting the radiation exposure area to a minimum.

Spiral ridge cyclotron

THE first high-power spiral ridge cyclotron —a new type atom smasher with more power in a smaller package—has gone into operation at the Los Angeles campus of the University of California. It is the third member of the family of cyclotrons, following the conventional cyclotron and the present-day synchrocyclotron or synchrotron. All three types were developed by University of California scientists. The three designers—physics professors J. R. Richardson, Bryon T. Wright and Kenneth R. Mackenzie—have stated that the 49 in. diameter machine can accelerate atomic particles to 50 MeV and a speed of 62,000 mile/sec. Key feature of the cyclotron is its spiral cloverleaf design, which allows continuous acceleration of protons, the nuclei of hydrogen atoms, in contrast to the bursts of acceleration in present synchrotrons. Because of its continuous acceleration, the spiral ridge cyclotron can, it is claimed, perform an experiment much faster than other cyclotrons in the same energy range. Its energy potential can also be extended, probably up to 600 MeV, without introducing any new design principles.

Workers protection

A CO-OPERATION agreement on the protection of workers against ionizing radiation dangers was signed recently between the Commission of the European Atomic Energy Community (Euratom) and the International Labour Organization (ILO). The collaboration provided for includes consultation on questions of common interest, the possible participation of observers in meetings organized by either side, the exchange of legal and statistical data and technical co-operation in the application of the agreement

Dreadnought ballast

TWENTY thousand lead bars of various sizes have been PVC coated by Plastic Coatings, Ltd., for use as ballast in *HMS Dreadnought*. The bars will lie adjacent to *Dreadnought's* hull, and need a protective anti-corrosive coating for insulation against electrolytic decomposition of the submarine's metal parts. Besides insulating the bars, this tough, highly adhesive, resilient coating ensures that they will resist knocks and damage when being placed in position. The lead bars were designed and manufactured by British Lead Mills, Ltd., using a pressure moulding method to ensure accurate weight and density. They were coated by immersion in a trough of paste based on Geon 121 PVC resin.

PVC-coated ballast for *HMS Dreadnought*

Reactor vessel interior

ROTTERDAMSCHE Droogdok Mij. NV, of Rotterdam, Holland, has received from the International General Electric Co. of the U.S.A., chief contractor for building Euratom's first nuclear power station in Italy, an order for the supply of the interior of a reactor vessel weighing 14,000 kg and having a diameter of 11½ ft.

Nuclear submarine turbines

ENGLISH Electric have been awarded the contract for the design and manufacture of the main propulsion steam turbines and condensers for Britain's second nuclear submarine. The machinery will be built at the company's Rugby works. The submarine was recently ordered by the Admiralty from Vickers-Armstrongs, Barrow.

Waveform recording

A DEVELOPMENT contract has been awarded to Cakewell Research & Electronics, Ltd., by the Atomic Energy Research Establishment at Harwell. The contract covers investigations into new methods of recording waveforms, with a view to achieving greater accuracies than was obtained with the oscilloscopes supplied for the ZETA project.

UK agents

CONTINENTAL Distributors, Ltd., have been appointed U.K. agents for Alderson Research Laboratories of the U.S.A. Alderson Laboratories manufacture a range of radiological test phantoms and anthropomorphic test dummies. Continental Distributors, Ltd., are also looking after U.K. sales and servicing of the automatic bi-dimensional radiochromatogram produced by Sansar Elettronica Per Fisica Nucleare of Italy.

Equipment and Materials

Items published in this monthly feature are compiled from manufacturers' current literature. Readers requiring further information should use the form at bottom of the page. Manufacturers are invited to send literature or details of their products for inclusion in this feature.

Pressure gauge

A new device for measuring pressures less than one-thousandth of one-billionth of atmospheric pressure at the earth's surface has been developed by Westinghouse Electric. This device, or photomultiplier ion gauge as it is known, is one of the developments resulting from project Sherwood, an ultra-high vacuum research programme supported by the U.S. Atomic Energy Commission. In this device the heated filament used in conventional pressure-measuring devices is eliminated and with it the associated undesirable effects. A beam of ultra-violet light is used to produce the required ionization of the gas, the beam is directed on to a metal surface which has the ability to release electrons under the stimulus of the ultra-violet rays. The electrons are guided on to a series of similar surfaces which multiply their speed and number. These electrons are used to form the ions which are collected and counted in the usual manner. **(MAR 1)**

Communication system

An intercommunication system for use with pressurized suits has been designed for the UKAEA by Spembly, Ltd. Great emphasis has been placed on ruggedness and reliability. Background air noise has been reduced considerably by incorporating a noise limiter in the personal receiver. An air filter to muffle the air supply has also helped to overcome a large amount of the background air noise. The control console (master), is capable of supplying up to 10 slaves. Direct communication between any slave and master is possible at all times without the operation of any external control. Similarly any slave can be in direct communication with any other slave. The master can speak to any slave by using the console or by simply connecting a standard head set. The headsets are of the government approved boom microphone type, and are fully weather-proofed and therefore suitable for indoor and outdoor working. Perfect fit and comfort is assured with this type of headset and large rubber earpads attenuate to a large degree any external noise, *i.e.*, any noise not coming through the amplifier circuit. The boom microphone can also be incorporated in the helmet of the pressurized suit which again increases ease and comfort for the operator working under the most adverse conditions. Other types of headset, however, can be supplied as required. To prevent damage to the internal components of the control console and personal receivers due to the inadvertent breaking down of a component, or a short circuit occurring, a protective relay is incorporated which operates when damaging overload currents are taken from the supply. This operation places the instrument in a safety condition and normal working cannot be restored until the instrument (control console) has been switched off, the fault removed, and the instrument switched on again. The power supply for the system is obtained from the mains and is transistor regulated. Any failure in mains supply can be easily overcome by switching to a 12v battery supply. Adequate lamps on the control console give an indication of the satisfactory working of the system. **(MAR 2)**

A typical arrangement of Spembly Intercommunication System portable power supply unit with an extension junction box

Remote-handling equipment

Three new items of nuclear remote-handling equipment have been introduced by Nuclear Equipment, Ltd., with the object of providing a fully comprehensive range capable of meeting all demands from

Cut along here

To: NUCLEAR ENERGY

147 Victoria Street, London, S.W.1

Please send further details of the following items in the EQUIPMENT & MATERIALS *feature for March, 1961*

Item No's ....

....

IS THIS ENQUIRY CONFIDENTIAL? YES | NO

Enquirer's Name .....

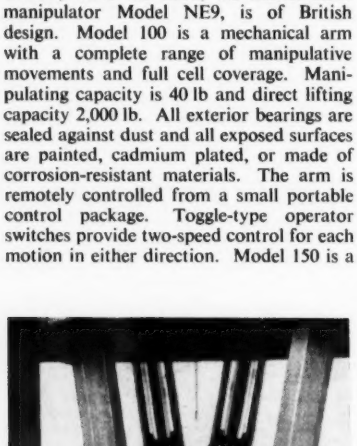
Position .....

Firm .....

Address .....

The powered mechanical arm Model 100

nuclear establishments. Two of these items, Model 100 and Model 150, have been designed by General Mills, Inc., of the U.S.A., while the third, the master slave manipulator Model NE9, is of British design. Model 100 is a mechanical arm with a complete range of manipulative movements and full cell coverage. Manipulating capacity is 40 lb and direct lifting capacity 2,000 lb. All exterior bearings are sealed against dust and all exposed surfaces are painted, cadmium plated, or made of corrosion-resistant materials. The arm is remotely controlled from a small portable control package. Toggle-type operator switches provide two-speed control for each motion in either direction. Model 150 is a compact arm specially designed for alpha-gamma handling in an airtight dry box. This arm can be mounted on a conventional overhead bridge, a boom, a vehicle, or a post. Control is by means of a small portable box with on-off push-button and individual lever action switches providing direction and infinitely variable speed controls for each motion. The master slave manipulator Model NE9 has been built to UKAEA specification and when required can be fitted with Harwell-type gas sealing. Loads of up to 30 lb can be fully manipulated and direct lifts can be carried out on loads up to 120 lb. Typical uses for the NE9 are the lifting and handling of fuel elements, the manipulation of valves, clamps and specialized power hand tools. The master slave is controlled by a pistol-grip type handle and every effort has been made to reduce operator fatigue. **(MAR 3)**



NE9 master-slave manipulator viewed from inside a typical "hot cell"

New Mobot

The Hughes Aircraft Company of the U.S.A., the parent company of Hughes International (U.K.), Ltd., has developed a Mobot Mark II. This is a successor to the Mobot Mark I and has three joints in each arm, at shoulder, elbow and wrist. Mobot Mark II has remarkable flexibility in its 6 ft steel arms and is designed for both heavy work such as lifting lead bricks or delicate work such as replacing electric light bulbs. This light touch has been achieved by inflated pads on the machine's arms in which pressure can be controlled carefully by the human operator. Two television cameras mounted on proboscis-like tentacles form the machine's eyes which focus on the work the hands are performing, and transmit a picture to the operator at a control console. This console may be over 100 ft away from the Mobot in another room. In this machine, motion is initiated by electrical actuators controlled by the operator. The control console has foot pedals to regulate speed of the vehicle and of arm movements. The operator watches two screens monitoring TV pictures of the Mobot's hand functions while manipulating toggle switches controlling the machine's shoulders, elbows, wrists, hands and grip. Other switches control the camera spotlights, focus, pan and tilt. Yet more switches control the steering mechanism and the tri-axial cable that sends command signals to the Mobot. It is hoped soon to control the Mobot by instructions recorded on tape. **(MAR 4)**

Amatron monitor

A new and very simple Geiger counter known as the "Amatron" portable radiation monitor has been produced by Photoelectronics (MOM), Ltd., to an approved Harwell design. The unit is ideally suited for teaching, demonstrating and showing the presence of beta/gamma emitting elements. Low energy beta radiation can be monitored by changing the GM tube. Visual and audible means are provided for indicating contamination by use of a large neon and 2½ in. loudspeaker. Provision is also made for using an external meter (0-500 microamps d.c.) or connecting up to an amplified loudspeaker system. The GM probe is separate and attached to the main unit by 6 ft of co-axial cable. The monitor can be either battery or mains operated. Radiation from an external source ionizes the gas in the GM tube which gives out a pulse large enough to trigger the neon circuit. The neon in turn supplies a pulse which gives an audible signal in the loudspeaker for each count. When the meter is inserted into the circuit by means of the jack plug, the current through the neon circuit is maintained and since this is proportional to count rate, the scale of the meter can be suitably calibrated. The probe consists of a Geiger Muller tube fitted into an octal valve base and contained in a protective sheath. Also contained in the sheath is a condenser and resistor fitted in series with the co-axial cable. To facilitate replacement, the tube and components are fitted to a base piece which can be completely withdrawn from the sheath. The probe is normally stored in a clip fixed on the side of the main case. Contained in the main unit is the neon indicator which projects from the front by approximately ½ in. in order to give good all-round visibility and is protected with a metal guard; a loudspeaker, with speaker transformer; a jack socket for meter connection, battery or mains unit (whichever is required) and associated components. Conversion from battery to mains is easily and quickly carried out. **(MAR 5)**

Mobot Mark II holding a Geiger counter

Single hand monitor

A new single hand monitor by EMI was shown recently at the Physical Society Exhibition. The monitor has been especially designed for the use of small laboratories or other establishments where there is a risk of radioactive contamination. It can deal with the hands of five people in one minute. Transistors are used to give a high degree of accuracy, and both audio and visual alarms are incorporated. The casing is made from Cellobond polyester resin reinforced with glass fibre. **(MAR 6)**

ISOTOPE WORLD

Isotope Symposium in Bangkok

A symposium was organized recently in Bangkok by the International Atomic Energy Agency on the use of radioisotopes in the study of endemic and tropical diseases. Abstracts of some of the papers presented are given below.

Use of Isotopes in the Study of Protein Metabolism and Protein Deficiencies, *A. S. McFarlane, National Institute for Medical Research, Mill Hill, London, U.K.*

CELL size appears to be controlled by the maintenance of a constant fractional rate of protein catabolism. The principle underlying this, which is discussed, appears also to be the basis of a homeostatic mechanism affecting the plasma proteins of man and higher animals and it can be used to explain satisfactorily numerous observations in the field of malnutrition.

Isotopes have been used in two main ways in studies of this kind: (*a*) to determine body parameters (pool sizes) by isotopic dilution in normal and undernourished people, and (*b*) to measure rates of synthesis and catabolism using labelled amino-acids and proteins. Difficulties which arise in executing and interpreting both kinds of measurement in clinical nutritional investigations are reviewed. Although these are formidable it is concluded that isotopic techniques offer important advantages, and in some instances are indispensable. Recent examples of their use are critically examined in the light of the following.

In a hypothetical equilibrium system comprising a central (plasma) pool exchanging its amino acids with satellite protein ones, kinetic theory, which is illustrated with analogue computer curves, shows that a reduction in the amino acid pool size brings about disproportionately large increases in the fraction of total radioactivity entering and leaving the faster protein pools. Increases of this kind have been recorded following injury, malnutrition or experimental protein depletion—all conditions associated with reduced plasma amino acid levels—and the picture generally appears to support the validity of the model which can be recommended for the analysis of nutritional data.

While isotope investigations have shed much light on the nature of animal protein reserves they have not been so successful in providing a reliable measure of their extent. Technical advances which are anticipated may be expected to alter this situation.

The Use of Radioisotopes in the Study of Vitamin B12 and Folic Acid Deficiencies, *D. L. Mollin, Postgraduate Medical School, London, U.K.*

DEFICIENCY of vitamin B12 and/or folic acid gives rise to a complex deficiency state, the most characteristic feature of which is megaloblastic anaemia. This condition has been investigated with many different labelled compounds. Thus C14- and H3-labelled amino acids, purines and other nucleo-protein precursors have been used to try to elucidate the biochemical defect underlying the megaloblastic change, while N15-labelled glycine, Fe59 and Cr51 have been used to study the rate of red cell production and destruction. However, the isotope-labelled materials which have proved to be of the greatest practical value in these conditions are radiocobalt-labelled B12 or H3-labelled folic acid.

Using these materials it is possible to determine whether the deficiency is due to malabsorption and, if this is so, to demonstrate the nature of the absorption defect causing the malabsorption. This last is possible because alterations in B12 and folic acid absorption reflect lesions in different parts of the gastro-intestinal tract: defective B12 absorption being associated with gastric and ileal lesions, defective folic acid absorption being associated with jejunal lesions. Furthermore in a given syndrome the absorptive defect can be reversed by a procedure which is characteristic of the particular syndrome. If such results are then correlated with other gastro-intestinal and haematological tests the cause of the malabsorption syndrome can be diagnosed with precision.

In addition the pathogenesis of this individual syndrome can be studied by following the alterations in function that occur as the disease progresses or improves with treatment.

The metabolism and distribution of absorbed or injected B12 and folic acid can also be investigated, such studies being useful for diagnosing deficiency due to an increased demand for the vitamins.

The Use of Isotopes in the Study of Tropical Sprue, *S. J. Baker, Christian Medical College Hospital, Vellors, S. India.*

TROPICAL sprue is a disease of unknown aetiology characterized in its more severe forms by diarrhoea, asthenia, weight loss, steatorrhoea and other manifestations. Milder forms also exist and may exhibit only isolated biochemical defects. Problems of differential diagnosis frequently arise especially differentiation from intestinal tuberculosis, chronic pancreatic disease, Addison's disease, pernicious anaemia, etc.

Radioisotopes may be used as aids in diagnosis and also in a more fundamental study of the underlying defects. In diagnosis, use has been made chiefly of fats labelled with I131 or C14. The value and limitation of these will be discussed.

Labelled vitamin B12 has proved particularly useful in studying the pathogenesis of B12 deficiency in sprue, and the author's experience with this will be presented. Defective B12 absorption in a small number of cases is associated with defective intrinsic factor secretion. The more usual defect, however, is associated with an intestinal lesion or lesions, preventing absorption even in the presence of intrinsic factor.

Evidence is presented to show that the pattern of malabsorption in a particular case may change from time to time, and it is suggested that this is due to a changing pattern of biochemical disturbances.

An attempt has been made to initiate a study of the nature of these biochemical disturbances. Mucosal specimens obtained by a multiple-retrieving-biopsy-tube have been used in in-vitro studies of the uptake of C14-labelled stearic acid, and other C14-labelled substances.

The Use of Isotopes in the Study of Iron Metabolism, *T. H. Bothwell, Department of Medicine, Medical School, University of the Witwatersrand, Johannesburg, South Africa.*

RADIOACTIVE isotopes of iron have contributed considerably to present concepts of iron metabolism. Of the many facets which have been studied most attention has been directed to the absorption and excretion of the metal and to the kinetics of its transport within the body.

In the normal adult male only small amounts of iron are excreted and these losses are balanced by the amounts absorbed from the gut. Although it is apparent that variations in the rate of absorption are of importance in the maintenance of iron balance there is still no clear understanding of how this is achieved. However, several factors seem to be of importance. These include: (*a*) the amount and form of the iron presented to the gut; (*b*) the functional integrity of the intestinal

mucosa; (*c*) the state of the body's iron stores; and (*d*) the activity of the erythroid marrow.

In the metabolism of iron within the body the plasma occupies a central role since all the iron being transported from one site to another passes through this compartment. Quantitative kinetic measurements using tracer amounts of Fe59 have shown that most of this iron is concerned with haemoglobin production and that erythropoietic activity is the major factor determining the amount of iron passing through the plasma. Using this approach it has been possible to define the patterns of red cell production in a variety of conditions. Since the techniques involved are simple ones they can be easily applied to the routine work-up of haematologic problems.

The Use of Isotopes in Study of Blood Loss Due to Parasites, *M. Roche, Institute Venezolano de Investigaciones Cientificas, Caracas, Venezuela.*

IT HAS been shown that radioactive chromium (Cr51) tagged on to circulating erythrocytes is not normally excreted in the faeces in significant quantities; nor is Cr51 reabsorbed from the gastro-intestinal tract. Hence, by injecting into human subjects their own red blood cells, tagged with Cr51 it is possible to measure the amount of blood lost into the intestinal tract through a bleeding lesion. The method has been applied in 35 hookworm-infected patients; intestinal blood losses varied from 2.0 ml/day to 251.5 ml/day, in rough agreement with the intensity of infection. In pure Necator americanus infections, blood loss per worm per day was found to be on the average 0.03 ml, with a range of 0.01 to 0.06.

Simultaneous ova counts by the Caldwell method and blood loss measurements have been satisfactorily performed on 31 patients. On the average, there was a loss of 20.6 ml/million ova $\pm$ 2.4 (standard error) with a rough correlation between blood loss and number of ova.

Expressed in a less accurate, but clinically more useful way, blood loss was 2.2 ml/1,000 ova/gm/day $\pm$ 0.06 (standard error). Thus, by performing ova counts, a rough idea can be obtained as to the importance of blood loss as a contributing factor to the anaemia in a given patient.

Not all iron lost into the intestinal tract appears in the faeces. By labelling circulating red blood cells with both Cr51 and radioactive iron (Fe59), it has been possible to show, in 14 infected patients, that intestinal iron losses ranged from 2.74 to 21.34 mg/day, while faecal losses varied from 1.80 to 16.24 mg/day. On an average, 44.1 per cent. of the intestinal iron lost was reabsorbed, with a range of 13.1 to 76.4 per cent. In non-infected, non-anaemic patients, the proportion of iron reabsorbed appeared to be much less.

Radioactive labelling with Cr51 has also been used to measure the quantity of blood sucked and ejected by Ancylostoma caninum in vitro, with the help of a specially designed apparatus. In eight experiments with 219 hookworms, this quantity was found to be of the order of 46 to 60 cu.mm of blood per Ancylostoma per 24 hr. A general discussion of isotope methods for the measurement of blood loss is also included.

The Use of Radioisotopes in the Study of Haemolytic Anaemia with particular reference to Haemoglobinopathies in Thailand, *Vikul Viranuvatti, University of Medical Sciences, School of Medical Technology, Siriraj Hospital, Bangkok, Thailand.*

HAEMOLYTIC anaemia due to abnormal haemoglobins is a serious problem in South-east Asia, especially Thailand. The geographical distribution of abnormal haemoglobins shows a high incidence of Haemoglobin E among the Burmese and Thais, and also the presence of Haemoglobin H among the Chinese and Thais too. The clinical manifestation of abnormal haemoglobin in these groups is in the forms of Thalassaemia-Hb.E disease, Hb.E trait, Homozygous E. and Thalassaemia-Hb.H disease. The main clinical symptoms are varying degrees of haemolysis and splenomogaly.

Radioisotopes may be used in studies of haemolytic activity by estimating the life span of the red cells, thus providing useful information regarding the pattern and also, possibly, the sites of red cell destruction. The survival time of red cells from normal subjects and patients with Thalassaemia-Hb.E disease and Thalassaemia-Hb.H disease were studied using the Cr51 method of Mollison and Veall together with *in vivo* surface counting to determine the sites of destruction of red cells. The survival time of red cells in patients with Thalassaemia-Hb.E disease was definitely shorter but in the very few cases studied *in vivo* counting no definite conclusion could be drawn regarding sites of destruction. The survival time of red cells in cases of Thalassaemia-Hb.H disease was shorter than that in Thalassaemia-Hb.E disease but surface counting results were again inclusive.

The Problem of Endemic Goitre as Studied with Radioiodide, *John B. Stanbury, Massachusetts General Hospital, Boston, Massachusetts, U.S.A.*

THE CENTRAL problems of endemic goitre are the physiology of the abnormal gland, and the aetiological factors which cause the disease. The pathology of the disease, its demography, clinical impact, course, prevention, and therapy were solved at least partly before the introduction of radioisotope methods of study.

With one exception recent studies from laboratories the world over have disclosed that the thyroid of the endemic goitre patient is unusually avid for iodide and turns iodide over rapidly. The quantity of hormone secreted seems to diminish with increasing severity of the endemia. The avidity of the gland for I131 is inversely related to the amount of stable iodide which is available daily to the patient. These glands appear to be under normal pituitary control because function is suppressed by standard doses of desiccated thyroid. When supplied with normal amounts of dietary iodide they slowly reach a new equilibrium state. Only a type of endemic goitre found in Tasmania and Australia has been attributed to a goitrogenic agent. This is obtained through milk because of a goitrogenic substance available to grazing animals.

The role of genetic factors has been suspected but not proved in the aetiology of endemic goitre. Five types of specific biochemical defects are now recognized which impair the function of the gland and result in goitre and hypothyroidism. Many of these patients (presumed homozygotes for a defective gene) have relatives with goitre but no hypothyroidism (presumed heterozygotes). The metabolic activity in at least two types can be circumvented by sufficient dietary iodide. Thus the possibility exists that partial genetic defects may augment the effect of iodide deficiency in causing goitre.

Each endemia must be treated individually in a search for the aetiologic factors. These may be iodide deficiency, dietary goitrogens, genetic factors, or a combination of the three. Presently available tools for thyroid research, especially those employing I131, should be adequate for resolving the nature of most endemic goitres.

The Use of Radioiodine in Endemic Goitre Investigations, *Paulo C. Campos, University of the Philippines, Manila, Philippines.*

A METHOD of investigation of endemic goitre with emphasis on the use of radioisotopes was presented, using one endemic locality as an example. A physician, nutritionist and aides conduct a systematic investigation. Each member of the population is examined with emphasis on the neck. Signs and symptoms pertinent to thyroidal functions are noted. The data taken include the economic status, occupation, years in the locality, age, sex, number of pregnancies and abortions, duration of goitre and medications taken. The family tree is scrutinized for the presence of goitre, cretinism, deaf-mutism and mental disease.

The dietary practice of the community and especially of the goitrous patients is investigated. Locally available food commodities and favourite family foods are noted. Representative 24 hr food samples are collected at random and examined quantitatively together with water samples for iodine, calcium and thiocyanate content and other goitrogens.

Patients are picked at random for laboratory evaluation. On the first day the basal metabolic rate, protein-bound iodine, sugar and cholesterol levels are determined. The patient is given a tracer dose of radioactive iodine. The 24 hr urinary excretion of labelled iodine is determined. The following day the neck uptake is counted and the PBI131 conversion ratio measured.

One gramme of thiocyanate is then given and the uptake repeated after the first, second and third hours. After two or three weeks the neck is examined for any residual radioactivity. If there are no residual counts labelled diiodotyrosine is given and the first and second hour urine samples are analyzed chromatographically. Two weeks later one millicurie of radioactive iodine is given and chromatographic analysis of the plasma is done.

Preliminary results of a campaign of this type at present carried out in some localities in the Philippine islands are given. It is hoped that further work will provide a better understanding of the nature of the metabolic defect and of the role of environmental factors involved in the aetiology of the types of goitre seen.

Water and Electrolytes in Tropical Conditions, *C. Leithead, Liverpool School of Tropical Medicine, University of Liverpool, Liverpool, U.K.*

THE PROBLEMS of tropical medicine are concerned with the physiological adjustments of the body to such factors as the ambient environment, the intake of foodstuffs, electrolytes and water, and specific disease processes originating from infection, dietary imbalance or deficiencies and poisons. The pattern of normal life and the progress of disease are further influenced by a background of genetic factors which may affect the reaction of the human host to infection or determine his response to environmental or nutritional conditions. In this respect knowledge of the "normal" is essential and for this reason the human individual is briefly considered in both temperate and tropical environments and in health and disease.

Radioactive isotopes have already proved themselves invaluable in the study of many of these problems and will be increasingly significant

as they become more easily available and techniques are simplified and improved. Certain very broad areas of study are considered. These include the control of water; electrolyte balance in the normal and diseased human subject, especially in regard to the part played by the adrenal corticosteroids, including aldosterone.

Particular reference is made to (i) the results of exposure to hot ambient temperatures (acclimatization and clinical effects); (ii) the reactions of the body to cholera and other dehydrating diseases, and to certain oedematous states; (iii) some problems of acute renal failure; (iv) the water: electrolyte pattern in the pathogenesis of malaria.

In addition, the phenomena of haemolysis and the metabolism of iron in malaria are briefly discussed. In each case some of the relevant information is reviewed and suggestions are made concerning profitable areas for the use of isotopes for future research.

The Use of Isotopes in the Study of Body Composition and Electrolyte Metabolism, *N. Veall, Guy's Hospital Medical School, London, U.K.*

ISOTOPE methods for the estimation of total body water, extracellular fluid and plasma volume, exchangeable sodium, potassium and albumin are now well established. Except in the case of the hydrogen isotopes the measurement techniques are relatively simple and can easily be adapted to suit locally available facilities. In general, measurement of a single body fluid compartment or exchangeable electrolyte pool is of limited value; the current tendency is toward the simultaneous measurement of most or all of the above parameters. This can, in fact, be done in several ways. The experimental accuracy for each measurement is of the order of ± 3 per cent. and is probably well within the range of physiological variation in the normal individual.

In studies confined to sodium metabolism the use of Na22 and whole body counting is particularly useful, especially under conditions where the facilities of a metabolic ward are not available. In the steady state serial, specific activity measurements make whole body activity measurements unnecessary. The use of tritium (or deuterium) in this way provides the only direct method for studying the turnover of the total body water.

The direct measurement of total body liquid content seems to be of considerable potential value partly because of its importance in nutritional studies and partly because of the desirability of using the lean body mass in preference to body weight as a standard of reference in many physiological studies. If the radioactive assay equipment is available the inert gases such as Kr85 and Xo133 can be used for this determination, otherwise it might be preferable to use ordinary nitrogen. The indirect estimation of lean body mass from total body water measurements would appear to be particularly suspect under tropical conditions.

Instrumentation in tropical or under-developed countries has its special problems which are discussed. There is an important requirement for a simple yet accurate technique for the assay of tritium in urine or plasma. It is probable that an ionization chamber method would best meet this requirement.

The short radioactive half-lives of isotopes such as Na24, K42 and Br82 result in low radiation dosage to the patient, but imply considerable supply difficulties. However, experience indicates that it makes little practical difference whether one is 60 or 6,000 miles from the source of supply.

Atomic Energy in Entomological Studies of Endemic and Tropical Diseases, *Dale W. Jenkins, Entomology Division, Fort Detrick, Maryland, U.S.A.*

RADIOISOTOPES and radiation have contributed greatly in solving entomological problems in endemic and tropical diseases. About 500 publications have been reviewed on the uses of atomic energy in the study and control of medically important insects and their relation to human disease. Radioisotopes have enabled solutions to research and control problems that have been difficult or impossible by conventional methods. The value and practicability of this research tool is discussed with relation to epidemiological studies on dispersal, migration, life history, populations, and disease transmission by arthropod vectors. The uses of atomic energy in control of arthropods by insecticides, irradiation and sterilization, and natural control are reviewed. The uses of radioactive materials in studying problems of the relationships of disease vector insects and parasites to animal and human hosts are presented.

Suggestions and recommendations for new and additional studies using radioisotopes and radiation are made for helping solve outstanding problems in the field of endemic and tropical diseases. Coordinated use of irradiation, insecticides, special chemicals and hormones special genetic characters, and natural control of pest and disease vector arthropods is suggested. Use of irradiation in learning the genetics of medically important insects is a promising new field that may provide sterile interseces and hybrids, genes causing abnormal sex ratios, sterility factors, and other characters that may present new methods of insect control. Radioisotopes provide a valuable tool in studying acological relationships in promising parasite and predator control of medically important insects. Use of atomic energy in developing these new control methods may help to solve critical insecticide resistance problems now facing us.

Entomological Problems in Tropical Medicine, *L. J. Bruce-Chwatt, World Health Organization, Geneva, Switzerland.*

THE AIMS of medical entomology are the identification of arthropod vectors responsible for the transmission of the agent of the relevant disease, the study of the role played by the vector and the development of methods for control or elimination of the vector.

Much of the knowledge pertaining to the arthropods and to the diseases carried by them is still in the descriptive stage. Knowledge of taxonomy, morphology, anatomy, histology and physiology of arthropods is fundamental to the sound approach to medical entomology but the dynamics of the relationship between the agent and the disease its host (whether definitive or intermediate) and the environment cannot be understood without an ecological approach. Without such understanding many attempts at controlling the vector are doomed to failure.

Four important tropical arthropod borne diseases have been selected as an example of the importance of the ecological approach to the problem of their control or eradication: malaria, trypanosomiasis, scrub typhus, onchocerciasis.

Among many new methods developed for the investigation of the natural ecology of arthropod vectors or for the studies connected with their response to modern insecticides the use of radioisotopes is one of the most promising, providing that they are properly used. Radioisotopes are exquisitely sensitive and specific analytical tools, but they are not more than tools and the results obtained depend entirely on the judicious approach to the whole research problem for which they will be used.

Marking and Release Experiments with a Tropical Mosquito by the Use of Radioisotopes, *M. T. Gillies, East African Institute of Malaria and Vector-borne Diseases, Amani, Tanganyika.*

AN ACCOUNT is given of experiments that formed part of a field study on the dispersion and longevity of Anopheles gambiae in East Africa. The mosquitoes were reared in the laboratory and labelled by the introduction of either P32 or S35 into the larval breeding pans. Releases were made in series, using these two isotopes in regular alternation. Recaptures were recognised by autoradiography. The particular isotope present in each specimen (and hence the date of release) was identified by a simple method for discriminating between high and low energy beta particles. Of some 60,000 mosquitoes released, 450 were recaptured. The recapture rate of females was 0.5 per cent. Parallel experiments on a similar scale were done with mosquitoes marked with paint, and similar results were obtained.

The results showed that the movement of mosquitoes was non-random and related primarily to the distribution of human settlements. Marked females were recaptured up to 23 days after release, and a single male at 30 days. The recapture rate of marked females declined with age by 16 per cent/day. This rate of loss was about double the mortality rate estimated for natural populations in the same area, and it was concluded that the discrepancy was connected with the use of artificially reared mosquitoes. It is considered that this factor places a limit on the use of marked insects for longevity studies in those species which cannot be collected in large numbers from natural waters.

Radioactive Tracer Techniques in Insect Biochemistry, *F. P. W. Winteringham, Agricultural Research Council, Pest Infestation Laboratory, Slough, Bucks., U.K.*

RADIOACTIVE tracer techniques combined with microfractionation techniques such as paper chromatography have provided powerful tools for studying the biochemical problems of insect control by chemicals.

An important aspect of this type of work is the separation, assay and identification of labelled compounds recovered in trace amounts from insect tissues. Automatic radiochromatographic techniques are available and identification may be established by co-chromatography with authentic compounds, and by studying the action of chemical reagents and specific enzymes on the labelled fraction.

A serious threat to the progress of tropical medicine is the increasing number of insect vectors displaying such high levels of resistance to the established insecticides that their use has had to be abandoned. Labelled insecticides have been extensively used for comparing their absorption, metabolism and excretion by normal and insecticide-resistant insects. The use of labelled dieldrin and its chemical relatives in this way has provided essential data on the mechanisms of resistance. The evidence to date strongly

suggests that resistance to dieldrin in Diptera is not due to detoxication or failure of the insecticide to penetrate the insect cuticle.

By labelling pools of related metabolites in vivo the effects of insecticides upon the insect may be studied. Labelled pools are formed in vivo by feeding or injecting insects with suitable labelled compounds.

Comparison of the labelled pools formed when (2-C14) acetate and (P32) PO_4^{3} were injected into adult insects provided valuable data on the biochemistry of insect nerve and muscle. For example, the significance of L-α-glycerophosphate in the carbohydrate metabolism of the flight muscle has been demonstrated, and studies made of the kinetics of acetylcholine metabolism in the nervous tissue of the intact insect.

Pools of metabolites labelled with C14 or P32 have been used for studying the mode of action of dieldrin and other insecticides in the insect. Thus, the organophosphorus insecticides appear to slow the rate of acetylcholine synthesis in vivo although they are without effect on the corresponding enzyme systems in vitro.

Caution must be exercised in the interpretation of tracer experiments applied to the problems of insect resistance. For example, a difference between the metabolism or excretion of a labelled insecticide by susceptible and resistant insects may not explain resistance but simply be a consequence of susceptibility.

Parasitological Problems in Tropical Medicine, *P. C. C. Garnham, Department of Parasitology, London School of Hygiene and Tropical Medicine, London, U.K.*

HUMAN parasitology in its widest sense includes the study of bacteria, viruses, rickettsiae, fungi, protozoa and helmuths, as well as the arthropod vectors. Although this is the best and most fruitful outlook, only the animal parasites could be considered here, *i.e.* the protozoa and helmuths, and even amongst them attention had to be confined to a few examples of outstanding problems, and in particular to questions which might prove soluble by employing radioisotope techniques.

The examples are largely drawn from conditions prevalent in the East. Such problems fall into three categories: (1) unknown stages of the life history of the parasite in successive hosts, (2) the role of an animal reservoir, and (3) the metabolism of the parasite and the reaction of the host, each representing a different face of the same complex, or host parasite relationship. Examples are given to illustrate some typical problems in protozoology and helminthology.

This symposium has excluded from its range the use of radiation in sterilizing or reducing the virulence of parasites, but these procedures may in the long run prove of greater value to mankind than the application of radioisotopes to the problems here discussed, where they have certain inherent disadvantages.

The Use of Isotopes in the Study of Helminth Life Cycles, *A. S. Dissanaike, University of Ceylon, Colombo, Ceylon.*

THE INFECTIVE stage larvae of helminths can be "activated" or "tagged" with P32 and other suitable isotopes with a view to following them up in the vertebrate host tissues. The following methods have been employed, depending on the type of life cycle involved:

(*a*) Larvae transmitted by invertebrate hosts, have been tagged by allowing them to develop in the tissues of previously activated vectors, *e.g.* Wuchereria bancrofti in Culex fatigans and Setaria digitata in Armigeres obturbans.

(*b*) Larvae having a free-living phase before entering the definitive host, have been tagged by feeding them on pre-activated food materials like bacteria, *e.g.* larvae of Necator amoricanus.

(*c*) Encysted larvae may be tagged by immersing the cysts in suitable solutions containing the isotope. The author and his associates have recently succeeded in using P32 to tag the progenetic metacercaria of a trematode Pleurogenoides sitapurii. The metacercaria develops into the adult in a frog. The tagged metacercariae have been followed up and identified as adults in the experimental frog. A similar technique may be adopted for other helminths in cysts and perhaps also for infective larvae of nematodes developing within the egg shell.

The author describes the above methods and goes on to discuss their possible use in elucidating certain unknown details of the life cycles of helminths of human importance. As P32-tagged larvae may not always be suitable in follow-up studies, radioisotopes which are gamma-emitting and long-lived are being tried out, and a few preliminary observations with Cs137 and I131 are discussed.

The Use of Isotopes in the Study of the Biochemistry and Physiology of Parasites, *W. P. Rogers, University of Adelaide, Adelaide, Australia.*

STUDIES on the biochemistry and physiology of parasites may be roughly classed as (*a*) those in which the primary interest is in the parasite largely as an independent organism, and (*b*) those in which the work is more directly concerned with the parasite-host relationship. Radioactive isotopes have been used as tracers in both these fields, but especially in (*a*). Here, tracers have been useful in the study of intermediary metabolism and in the examination of novel routes of metabolism such as those involved in the synthesis of volatile fatty acids excreted by some parasites. In this sort of work the advantages and technical problems in the use of radioactive tracers are largely similar to those in the study of the metabolism of free-living animals.

The balance between parasite and host is a delicate one which is easily disturbed by experimental procedures. For this reason, basic physiological features of (*b*), the host-parasite relationship, are often difficult to examine. It seems, however, that radioactive isotopes used as tracers and in radio-autographs would be especially useful, and, in fact, important results have been obtained with these methods. It is surprising, however, that the methods have not been used more widely. Apart from minor difficulties such as the dilution of labelled materials in host animals, or difficulties in equilibration which might sometimes arise, there seems to be no reason why the application of these methods should not be most profitable.

The Use of Isotopes in the Study of Diseases Caused by Protozoa, including Malaria, *H. H. Anderson, University of California Medical Centre, San Francisco, California, U.S.A.*

THE EXCEPTIONALLY high resistance of protozoa to radiation has been known for some time. For example, no aberrations of chromosomes were found after doses of 20,000 r (Cleveland and Day, 1941 (unpublished)). With paramecium, the mating reaction was arrested after exposure to 500,000 r and the symbiont was destroyed (Wicherman, 1948). Gamma ray effects on the trophozoites of Entamoeba histolytica were studied by Nasset and Kofoid (1928), utilizing radium needles in cultures. Ionization was comparatively low, since continuous exposure over 12 hours did not affect division of cells. Sadun *et al.*, (1950) found that 120,000 r of X-rays did not inactivate completely the growth of amoebae in cultures. Schneider and Porter (1960) utilizing radiocobalt (Co60) reported that 195,300 rad approached the lethal dose for trophozoites of E. histolytica. Cysts of the same strain (NRS) were about $^1/_{10}$ as resistant to gamma rays (Schneider, 1960).

In our laboratory, (Kerner *et al.*), E. histolytica has been labelled with radioactive yttrium, cerium and lanthanum. Growth in the cultures is not interfered with by concentrations up to 1:5,000 of yttrium nitrate after 48 hours exposure. A metallic coat develops, not only on the nucleus of the amoeba, but also on the cell wall, which is seen readily in unstained preparations. Further, the localization of rare earths in E. histolytica has been accomplished. Complexes form with nuclear constituents, probably due to strong affinity of rare earth metals for nucleic acid. It was also shown that cerium was capable of bonding with acid polysaccharide of both cytoplasm and nucleus. Thus not only nucleic acid, but acid polysaccharides of the cytoplasm and nucleus combine.

Doses of more than 1,000 r of X-rays are required to kill Plasmodium gallinaceum, but the host cannot tolerate such amounts (Bennison and Coatney, 1945). While many reports are contradictory on the use of X-rays in therapy of human malaria, it is certain that with tolerated doses there is little effect on parasitaemia. The development of Pl. gallinaceum may be arrested in mosquitoes (Aedes aegypti) by irradiation with phosphorus (P32) according to Hahn *et al.* (1950). Clark (1952) has shown that parasitized cells take up more P32 than normal cells. Fe55 and Fe59 given to plasmodium-infected Pekin ducks (Thompson, 1948 and 1949) exhibited no action on initial infection, morphology or staining reaction.

Other examples, including autoradiographic techniques, are reviewed.

NEW ISOTOPE EXPERIMENT MANUAL

A NEW manual entitled "Radioisotope Experiments for the Chemistry Curriculum" is now available from the Nuclear-Chicago Corporation of America. This manual has been prepared under a contract with the Office of Isotope Development of the American Atomic Energy Commission and is intended to be an introduction for the chemistry student to radioisotope techniques and to demonstrate the potentialities of this field. The experiments were developed and tested for laboratory groups of 30 students. The students themselves can prepare the samples, measure radioactivity and interpret results. In all there are 23 experiments, 10 are introductory and illustrate the properties of radioisotopes, radiation, and instruments used. The experiments are designed to fit easily into existing courses. Only basic nuclear detection equipment, a scaler, timer, Geiger tube and mount, is required to conduct the experiments. No previous experience is required of the instructor or students.

Research on coronary thrombosis and anti-biotics

RESEARCH on the subject of coronary thrombosis and anti-biotics is receiving considerable help from a simple micro-organism known as chlorella. This substance is found in stagnant ponds but can also be grown easily in the laboratory. Chlorella produces a range of vital substances very similar to those built up in the human body.

Scientists are using the substance to make these complex organic materials for use in research. Its molecules are intricate patterns of carbon, hydrogen and oxygen atoms and to distinguish them and study what happens to them during life processes, they must be "marked" in some way. This is best done by using radioactivity.

The carbon atoms are selected for marking but due to the complex nature of the molecules of these life substances and the fact that they may contain many carbon atoms, it has been found very difficult, using ordinary chemical methods, to replace more than one of these atoms by a radioactive carbon atom. If there are ten atoms of carbon in one of these molecules, the end-product will obviously be much less radioactive for a given amount than if all its carbon atoms were C14.

Such weakly-marked products are difficult to trace and, when they are destroyed during body processes, only the fraction containing the radioactive atom will be traceable.

Scientists at the UKAEA's Radiochemical Centre at Amersham have solved the problem by growing chlorella under closely-controlled sterile conditions in an atmosphere of radioactive carbon dioxide. The chlorella has no other source of carbon than the radioactive gas and all the carbon atoms of all the organic substances it evolves will be radioactive.

A £5,000 batch of radioactive chlorella can be grown in one or two weeks. But separation of the individual organic compounds it contains requires two or three months.

The world-wide demand for these is now so great that they are on order well ahead. Attempts are being made to simplify the growing process and turn it into a routine laboratory job which does not require supervision of highly trained scientists.

Once a batch of chlorella is grown —and a "batch" would be about 10 cc—separation work begins and the first step of all is to split the rather tough skins of these micro-organisms. At first this was done by subjecting a thick "soup" of chlorella to intense pressure (between 2,500 and 3,000 lb/sq.in.), and then allowing the soup to leak slowly through a needle valve. This is a rather inconvenient process with such small amounts so ultra-sounds are now used to do the job.

Centrifuging and freeze-drying of the product follow. The latter process is used because the chemicals would be destroyed by heat.

Final separation is achieved by paper chromatography. In this process a line of the material to be separated is drawn on porous paper, one end of which is placed in a solvent. The different substances in the material travel through the paper with the solvent at different rates and can be separated simply by cutting the corresponding strips of paper. The exact position of each line of pure organic compound is determined by exposing a film to the paper. The radioactivity from the compounds will blacken the film and make it simple to map their contours. When the different strips have been cut out, the pure products are washed off into the final solvent.

Some heart specialists believe a major cause of thrombosis to be the use of large quantities of saturated fatty acids such as beef, pork and mutton fats, in human diet. They think that if such fats could be replaced by unsaturated fatty acids such as maize oil or peanut oil, there would be less heart trouble. Chlorella produces a range of such unsaturated acids which can be marked radioactively and used to explore this theory.

Anti-biotic research is also benefiting because a number of amino-acids are available from the radioactive chlorella farm. These substances are found in the immensely complex protein molecules. Poisons produced by microbes are proteins and so are the substances which the human body produces to defend itself, the anti-toxins. The use of these labelled amino-acids can thus help the physiologists to find out just what a microbe does and the best way of killing it.

Trade Union concern about radiation dangers

THE INCREASING USE of nuclear energy for peaceful purposes and the implications for workers were discussed recently in Düsseldorf by 60 Trade Union experts, representing 30 national Trade Union federations in 16 European countries, the U.S. and Canada. The seminar was organized by the OEEC European Productivity Agency with the assistance of the OEEC European Nuclear Energy Agency and in collaboration with the Federal German Productivity Centre (RKW) and the German Trade Union Federation. Opening the seminar, Dr. Franz Meyers, Prime Minister of North-Rhine Westphalia, pointed out that the OEEC was the first international organization to organize a meeting of this kind.

Mr. Charles Fisher, of the Nuclear Research Centre at Saclay, France, Mr. J. F. Cameron of Wantage Research Laboratories and other speakers pointed out that radio-isotopes are now used in every branch of industry and agriculture, and in medicine, which means that nuclear questions are no longer the province of a few scientists but have been brought home to the general working public.

Several of the Trade Union delegates expressed concern at the danger to workers from overdoses of radiation and demanded that Union representatives should be brought in at every stage to ensure that care was taken to protect the worker, both in the design of the plant and in the day-to-day handling of radioactive sources. The meeting recognized, however, that too few Union representatives knew enough about the subject; and several delegates resolved to see what could be done in their respective countries to train Trade Union organizers to inspect industrial and agricultural undertakings with this in view.

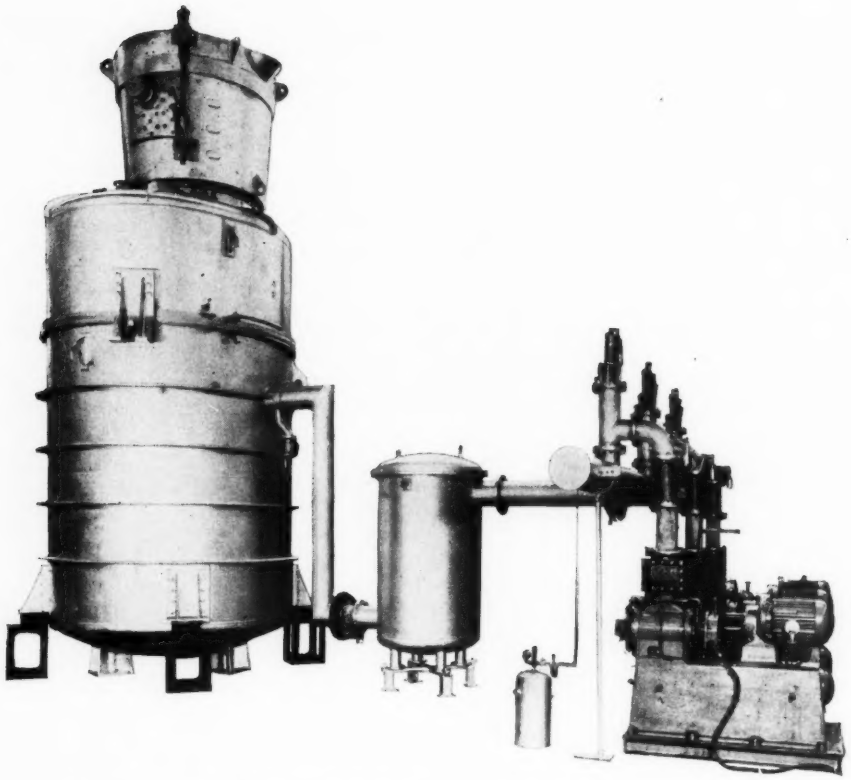
However, both Dr. H. Jammet, of Saclay and Dr. Gunter Friedrichs of the Industrie Gewerkschaft Metall, explained that the dangers could be grossly exaggerated, while Mr. G. Taylor (American Federation of Labour—Congress of Industrial Organizations) and Mr. Frederick Hayday (National Union of General and Municipal Workers) told the conference that they had found on the whole that existing safety regulations were adequate in themselves and were being properly applied.

Compensation for injuries received through radiation and the work done by the OEEC through its European Nuclear Energy Agency (ENEA) elaborating an international convention on this subject, which has been signed by sixteen member countries, were also discussed. It was pointed out that international agreements are necessary because if a serious accident occurs in a reactor in one country, the wind may well carry masses of radioactive particles to neighbouring countries.

The other aspect of nuclear energy which interests the Trade Unions is the question of whether it is likely to cause unemployment. Dr. Heimo Hardung-Hardung of ENEA predicted that nuclear-generated power would probably become competitive in price with traditional sources of power sometime between 1965 and 1970. But taking into account the growing needs of the world for energy—with special reference to underdeveloped countries lacking mineral resources—there would probably be a demand for all forms of energy for many years to come.

As to whether a growing use of radioisotopes would cause unemployment, several speakers considered it was impossible to separate this question from the general effects of automation, of which radioactive controls formed only a part.

There was a general demand for further Trade Union conferences on the subject of nuclear energy, each conference to be confined to one particular facet of the problem. At the same time, all the participants agreed that the seminar, which included a visit to the Nuclear Experimental Centre at Jülich, had greatly enhanced their understanding of the problems and had provided material for discussion with their colleagues on their return.



For the reduction of Hydrogen in steel

The VIA-VAC 15 TON DE-GASSING UNIT

Plant can be supplied in the range of 1 ton to 150 tons for the following processes:

Ingot casting in vacuum.

Re-heating in vacuum after pouring by Induction Heating.

Re-heating or casting in atmosphere after pouring in vacuum.

HIGH VACUUM CONSULTING
VIA-VAC
SERVICE TO INDUSTRY

VACUUM INDUSTRIAL APPLICATIONS LTD., **(Dept. N.E.E.) WISHAW, LANARKSHIRE, SCOTLAND**

Telephone: WISHAW 142 *Telegrams: "VIA-VAC, WISHAW"*

APPOINTMENTS

INTERSCHUTZ
International Exhibition of Fire Fighting Equipment, Safety Appliances & Radiation Protection
COLOGNE
23rd June—2nd July, 1961

The Exhibition will present a comprehensive show of all the latest safety devices in Industry, Civil Defence and Atomic Research.

Cologne will become the meeting place of specialists in these fields from all over the world.

INTERSCHUTZ offers you a unique opportunity of finding an International Market for your Products.

British Exhibitors please apply to:
M. NEVEN DU MONT,
123 Pall Mall,
London, S.W.1.
(Telephone: WHI 8211)

PLANNING FOR ELECTRICITY EXPANSION

The demand for electricity is doubling approximately every ten years. To plan for this expansion needs continuous study of the long term availability and use of resources for generation.

ENGINEERS ECONOMISTS
PHYSICISTS MATHEMATICIANS

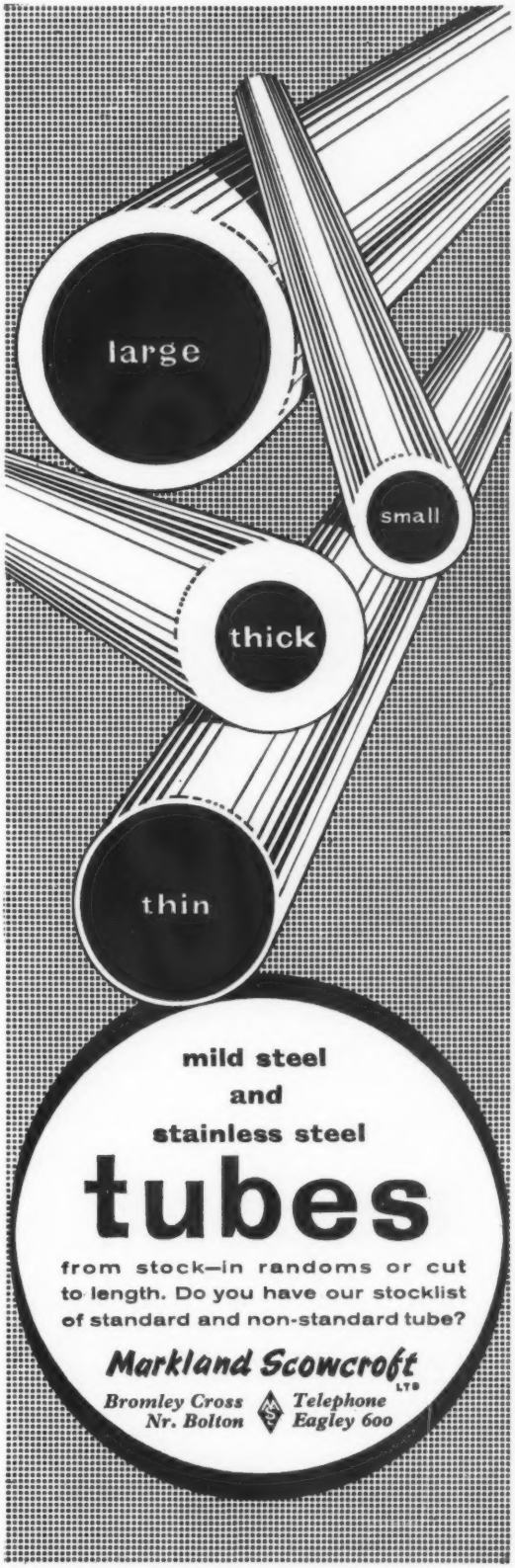
are invited to apply for appointments in the Development Section (Policy) of the Planning Department at the Central Electricity Generating Board's Headquarters in London, S.E.1.

The Section advises on certain technical and economic problems arising from the continuous growth of the industry, calling on the assistance of specialists in other Departments as necessary. Subjects at present under study include the longer term aspects of national energy resources, fuel supplies and transport, clean air, clean rivers, availability of water, nuclear and conventional generation developments.

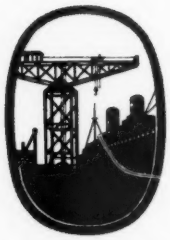
Applicants should have experience in the electricity supply industry or in one or more of the above fields of study. They should preferably hold a University degree or its equivalent or be members of an appropriate professional institution.

Salaries on scales within the range £1,165-£1,890 p.a., according to duties and responsibilities.

Applications marked "Confidential" and quoting Ref. No. NE/54 should be addressed to:—
Appointments Officer,
Central Electricity Generating Board,
24/30, Holborn, London, E.C.1,
to arrive not later than March 13th.



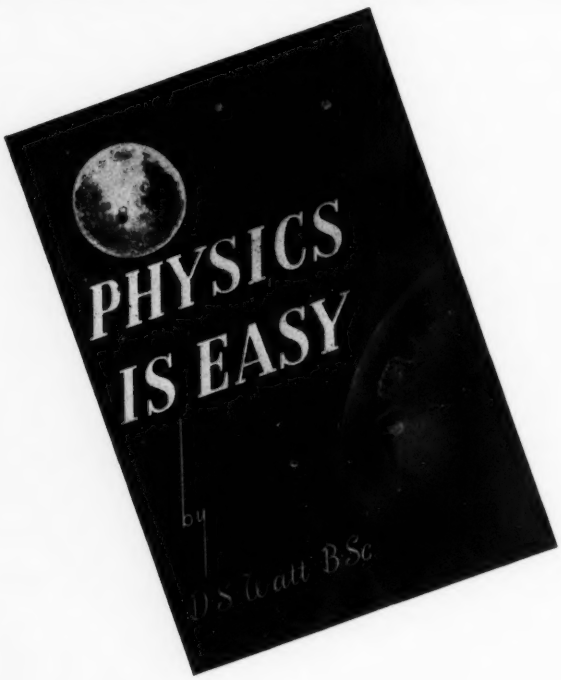
ENGINEERING MARINE WELDING & NUCLEAR ENERGY EXHIBITION



THE LARGEST EVENT OF ITS KIND IN THE WORLD

Olympia · London
April 20-May 4 1961

For full details write to the organisers:
F. W. BRIDGES & SONS LTD.
Grand Buildings, Trafalgar Sq, London, W.C.2



Physics is part of your life. You cannot get away from it. Whether you are a poet or photographer, a theologian or telegraphist, a baritone or a bus-driver, a knowledge of this subject will enrich you.

Size of the Book 8½ in. × 5½ in. and is in blue cloth. 560 pages with 123 diagrams. Send 63/- (which includes postage) for immediate attention.

PRINCES PRESS LIMITED, 147 VICTORIA STREET, S.W.1

Printed and Published by Princes Press, Ltd., 147, Victoria Street, Westminster, S.W.1.
Conditions of Sale and Supply.—This periodical is sold subject to the following conditions, namely, that it shall not, without the written permission of the publishers first given, be lent, resold, hired out or otherwise disposed of by way of trade except at the full retail price of three shillings and sixpence, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of trade; or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever

Send us a postcard . . .

. . . for SUBSCRIPTIONS

To:

- ☐ THE CONSULTING ENGINEER @ 42/-
- ☐ NUCLEAR ENERGY @ 42/-
- ☐ HEATING & AIR CONDITIONING @ 42/-
- ☐ THE CIVIL ENGINEER @ 42/-
- ☐ EUROPEAN ENGINEERING @ 42/-
- ☐ WORLD AIRPORTS @ 80/-

TOTAL TO PAY ON RECEIPT OF INVOICE £ s. d.

ORDER SENT .....196.....

INVOICE RECEIVED .....196.....

REMITTANCE SENT .....196.....

To: Subscription Dept.,

PRINCES PRESS LTD., 147, Victoria Street, London, S.W.1.

Please send the following journal(s) each month for one year commencing

.....*and invoice me for £*.....

- ☐ THE CONSULTING ENGINEER @ 42/- for 12 issues post free
- ☐ NUCLEAR ENERGY @ 42/- for 12 issues post free
- ☐ HEATING & AIR CONDITIONING @ 42/- for 12 issues post free
- ☐ THE CIVIL ENGINEER @ 42/- for 12 issues post free
- ☐ EUROPEAN ENGINEERING @ 42/- for 12 issues post free
- ☐ WORLD AIRPORTS @ 80/- for 12 issues post free

Mark journals required

Name.....

Position.....

Firm .....

Address..... *Signed*.....

cut here

. . . for INFORMATION

Journal .....

Issue .....*196*.....

Page .....

Editorial/Advertised item about which more details are required

.....

.....

.....

Enquiry sent.....196.....

Reply received .....196.....

CONFIDENTIAL? YES | NO

To The Editor of.....*

PRINCES PRESS LTD., 147, Victoria Street, London, S.W.1.

Please send further details of the editorial/advertised† item on page.....

of the.....*196*.....*issue.*

Brief identification of the item concerned:.....

.....

.....

Name.....

Position .....

Firm..... IS THIS ENQUIRY CONFIDENTIAL? YES | NO

Address .....

.....

..... *Signed* .....

* *Name of Journal*
† *Delete as appropriate*

cut here

. . . for ADVERTISING

Journal(s) of interest:

- ☐ THE CONSULTING ENGINEER
- ☐ NUCLEAR ENERGY
- ☐ HEATING & AIR CONDITIONING
- ☐ THE CIVIL ENGINEER
- ☐ EUROPEAN ENGINEERING
- ☐ WORLD AIRPORTS

Enquiry sent .....*196*.....

Details received .....*196*.....

Space reserved ....

.....

.....

To: General Advertisement Manager,

PRINCES PRESS LTD., 147, Victoria Street, London, S.W.1.

We are interested in advertising in the following journals. Please send full details

- ☐ THE CONSULTING ENGINEER
- ☐ NUCLEAR ENERGY
- ☐ HEATING & AIR CONDITIONING
- ☐ THE CIVIL ENGINEER
- ☐ EUROPEAN ENGINEERING
- ☐ WORLD AIRPORTS

Mark appropriate journals

Name .....

Position .....

Firm..... *Signed* .....

Address .....

.....

POSTAGE WILL BE PAID BY PRINCES PRESS LTD.

NO POSTAGE STAMP NECESSARY IF POSTED IN GREAT BRITAIN OR NORTHERN IRELAND

BUSINESS REPLY CARD
Licence No. S.W. 2154

Princes Press Ltd.,
Subscription Dept.,
147 Victoria Street,
London, S.W.1

POSTAGE WILL BE PAID BY PRINCES PRESS LTD.

NO POSTAGE STAMP NECESSARY IF POSTED IN GREAT BRITAIN OR NORTHERN IRELAND

BUSINESS REPLY CARD
Licence No. S.W. 2154

Princes Press Ltd.,
The Editor,
147 Victoria Street,
London, S.W.1

POSTAGE WILL BE PAID BY PRINCES PRESS LTD

NO POSTAGE STAMP NECESSARY IF POSTED IN GREAT BRITAIN OR NORTHERN IRELAND

BUSINESS REPLY CARD
Licence No. S.W. 2154

Princes Press Ltd.,
General Advertisement Manager,
147 Victoria Street,
London, S.W.1

Try this new IDEA at your factory

The new CORBY plant for British Sealed Beams Ltd., and other modern factories, have Brooks' Fan-powered 'Vertical Jet' roof extract units to discharge fumes and contaminated air high above building roof level. Brooks' Fan-powered Standard weathercap type Roof Units are used as fresh air intakes to unit heaters and input ventilation plants.

Architects:
Corby Development Corporation
Consulting Engineers:
Edward A. Pearce & Partners
Heating & Ventilating Contractors:
Arthur Heaton & Co. Ltd.

BROOKS
VENTILATION

Photograph by courtesy of William Gray & Co. Ltd.

All round protection against corrosion

. . lastingly ensured with

Wherever hot-wet metal surfaces are found—with temperatures above 200°F—'Apexior No. 1' prevents corrosion.

Easily applied by brush or spray this outstanding coating provides effective *low cost* protection for expensive boiler plant . . . means less costly maintenance. 'Apexior No. 1' minimises scale formation, ensures that any scale which does form will be easier to remove; heat transmission is improved and feed water will not be contaminated or discoloured.

For full information about 'Apexior No. 1' write today for booklet "Preventing Boiler Corrosion".

APEXIOR REGISTERED **No. 1**

BRITISH PAINTS LIMITED *Apexior Division*

Portland Road, Newcastle upon Tyne, 2 · Northumberland House, 303-306, High Holborn, London, W.C.1 · 31, Wapping, Liverpool.

SYDNEY · ADELAIDE · DURBAN · CAPE TOWN · CALCUTTA · TRINIDAD · NEW YORK · DUBLIN. *Our world-wide service is at your disposal for the asking*

BPL/A49